TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1888

VOL. XXI.

(Fourth of New Series)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE.

BY
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Director

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CORRIGENDA ET ADDENDA.

PAGE 33, line 37, and page 41, line 6, *for* "Maruaepuke" *read* "Mamaopuke."

Page 34, line 7, *for* "Wullerstorfii" *read* "Wulferstorfii."
,, 38, ,, 37, *for* "gladifolius" *read* "glastifolius."
,, 59, ,, 1, *after* "C." *insert* "(Lophocolea)."
,, 123, ,, 17, *for* "resting" *read* "nesting."
,, 260, bottom line, *for* "Geological" *read* "Zoological."
,, 348, line 11 from bottom, *for* "flow" *read* "floor."
,, 351, ,, 3, *for* "microscopic" read "macroscopic."
,, 395, ,, 8 from bottom, *for* "Tokomaru" *read* "Anaura."
,, 415, ,, 10 from bottom, *for* "one" *read* "our."
,, 418, ,, 18, *for* "Copeland" *read* "Coupland."
,, 446, ,, 7 from bottom, *for* "$\frac{-}{p}$" *read* "$\frac{a}{p}$".

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ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867."

BOARD OF GOVERNORS.

(EX OFFICIO.)

His Excellency the Governor.

The Hon. the Colonial Secretary.

(NOMINATED.)

The Hon. W. B. D. Mantell, F.G.S.; W. T. L. Travers, F.L.S.; Sir James Hector, K.C.M.G., M.D., F.R.S.; Ven. Archdeacon Stock, B.A.; Thomas Mason; the Hon. G. M. Waterhouse, M.L.C.

(ELECTED.)

1888.—James McKerrow, F.R.A.S.; W. M. Maskell, F.R.M.S.; A. S. Atkinson, F.L.S.

MANAGER: Sir James Hector.

HONORARY TREASURER: Hon. G. M. Waterhouse, M.L.C.

SECRETARY: R. B. Gore.

ABSTRACTS OF RULES AND STATUTES.

GAZETTED IN THE "NEW ZEALAND GAZETTE," 9TH MARCH, 1868.

SECTION I.

Incorporation of Societies.

1. No Society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1867," unless such Society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than fifty pounds sterling annually, for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the Chairman for the time being of the Society.

2. Any Society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said Society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £50.

3. The by-laws of every Society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the Museum and Library of the New Zealand Institute.

4. Any Society incorporated as aforesaid, which shall in any one year fail to expend the proportion of revenue affixed in manner provided by Rule 3 aforesaid, shall from thenceforth cease to be incorporated with the Institute.

5. All papers read before any Society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and may then be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

Regulations regarding Publications.

(*a.*) The publications of the Institute shall consist of a current abstract of the proceedings of the Societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute," and of transactions, comprising papers read before the incorporated Societies (subject, however, to selection as hereinafter mentioned), to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Institute shall have power to reject any papers read before any of the incorporated Societies.

(*c.*) Papers so rejected will be returned to the Society in which they were read.

(*d.*) A proportional contribution may be required from each Society towards the cost of publishing the Proceedings and Transactions of the Institute.

(*e.*) Each incorporated Society will be entitled to receive a *proportional* number of copies of the Proceedings and Transactions of the Institute, to be from time to time fixed by the Board of Governors.

(*f.*) Extra copies will be issued to any of the members of incorporated Societies at the cost-price of publication.

6. All property accumulated by or with funds derived from incorporated Societies, and placed in the charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1867," and to the foregoing rules, all Societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the Chairman and countersigned by the Secretary of any Society, accompanied by the certificate required under Rule No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing rules of the Institute are complied with by the Society.

SECTION II.

For the Management of the Property of the Institute.

9. All donations by Societies, public departments, or private individuals to the Museum of the Institute shall be acknowledged by a printed form of receipt, and shall be duly entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

10. Deposits of articles for the Museum may be accepted by the Institute, subject to a fortnight's notice of removal to be given either by the owner of the articles or by the Manager of the Institute, and such deposits shall be duly entered in a separate catalogue.

11. Books relating to natural science may be deposited in the Library of the Institute, subject to the following conditions:—

(*a*.) Such books are not to be withdrawn by the owner under six months' notice, if such notice shall be required by the Board of Governors.

(*b*.) Any funds especially expended on binding and preserving such deposited books at the request of the depositor shall be charged against the books, and must be refunded to the Institute before their withdrawal, always subject to special arrangements made with the Board of Governors at the time of deposit.

(*c*.) No books deposited in the Library of the Institute shall be removed for temporary use except on the written authority or receipt of the owner, and then only for a period not exceeding seven days at any one time.

12. All books in the Library of the Institute shall be duly entered in a catalogue, which shall be accessible to the public.

13. The public shall be admitted to the use of the Museum and Library subject to by-laws to be framed by the Board.

SECTION III.

The Laboratory shall for the time being be and remain under the exclusive management of the Manager of the Institute.

SECTION IV.

OF DATE 23RD SEPTEMBER, 1870.

Honorary Members.

Whereas the rules of the Societies incorporated under the New Zealand Institute Act provide for the election of Honorary Members of such Societies, but inasmuch as such Honorary Members would not thereby become members of the New Zealand Institute, and whereas it is expedient to make provision for the election of Honorary Members of the New Zealand Institute, it is hereby declared—

1. Each incorporated Society may in the month of November next nominate for election as Honorary Members of the New Zealand Institute three persons, and in the month of November in each succeeding year one person, not residing in the colony.
2. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as Honorary Members is recommended, shall be forthwith forwarded to the Manager of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.
3. From the persons so nominated the Governors may select in the first year not more than nine, and in each succeeding year not more than three, who shall from thenceforth be Honorary Members of the New Zealand Institute, provided that the total number of Honorary Members shall not exceed thirty.

LIST OF INCORPORATED SOCIETIES.

NAME OF SOCIETY.	DATE OF INCORPORATION.
Wellington Philosophical Society	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury	22nd Oct., 1868.
Otago Institute	18th Oct., 1869.
Westland Institute	21st Dec., 1874.
Hawke's Bay Philosophical Institute	31st Mar., 1875.
Southland Institute	21st July, 1880.
Nelson Philosophical Society	20th Dec., 1883.

OFFICERS OF INCORPORATED SOCIETIES, AND EXTRACTS FROM THE RULES.

WELLINGTON PHILOSOPHICAL SOCIETY.

Office-bearers for 1889.—*President*—A. de B. Brandon, B.A.; *Vice-presidents*—C. Hulke, F.C.S., A. McKay, F.G.S.; *Council*—R. H. Govett, Sir James Hector, K.C.M.G., M.D., F.R.S., W. T. L. Travers, F.L.S., E. Tregear, F.R.G.S., H. P. Higginson, M.Inst.C.E., Hon. R. Pharazyn, M.L.C., F.R.G.S., W. M. Maskell, F.R.M.S.; *Secretary and Treasurer*—R. B. Gore; *Auditor*—T. King.

Extracts from the Rules of the Wellington Philosophical Society.

5. Every member shall contribute annually to the funds of the Society the sum of one guinea.

6. The annual contribution shall be due on the first day of January in each year.

7. The sum of ten pounds may be paid at any time as a composition for life of the ordinary annual payment.

14. The time and place of the general meetings of members of the Society shall be fixed by the Council and duly announced by the Secretary.

AUCKLAND INSTITUTE.

Election of Officers for 1889.—*President*—Josiah Martin, F.G.S.; *Vice-presidents*—S. Percy Smith, F.R.G.S., Professor A. P. Thomas, F.L.S.; *Council*—Professor F. D. Brown, C. Cooper, Mr. Justice Gillies, W. Fidler, E. A. Mackechnie, T. Peacock, M.H.R., J. A. Pond, Rev. A. G. Purchas, M.R.C.S.E., J. B. Russell, Rev. W. Tebbs, Jas. Stewart; *Secretary and Treasurer*—T. F. Cheeseman, F.L.S., F.Z.S.; *Auditor*—J. Reid.

Extracts from the Rules of the Auckland Institute.

1. Any person desiring to become a member of the Institute shall be proposed in writing by two members, and shall be balloted for at the next meeting of the Council.

4. New members on election to pay one guinea entrance-fee, in addition to the annual subscription of one guinea, the annual subscription being payable in advance on the first day of April for the then current year.

5. Members may at any time become life-members by one payment of ten pounds ten shillings, in lieu of future annual subscriptions.

10. Annual general meeting of the Society on the third Monday of February in each year. Ordinary business meetings are called by the Council from time to time.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

Office-bearers for 1889.—*President*—H. R. Webb, F.R.M.S.; *Vice-presidents*—Professor F. W. Haslam, M.A.; S. Hurst Seager, A.R.I.B.A.; *Hon. Treasurer*—H. R. Webb, F.R.M.S.; *Hon. Secretary*—R. M. Lang, M.A.; *Hon. Auditor*—C. R. Blakiston; *Council*—G. Hogben, M.A., J. T. Meeson, B.A., Professor Hutton, F.G.S., H. O. Forbes, W. H. Symes, M.D.

Extracts from the Rules of the Philosophical Institute of Canterbury.

21. The ordinary meetings of the Institute shall be held on the first Thursday of each month during the months from March to November inclusive.

35. Members of the Institute shall pay one guinea annually as a subscription to the funds of the Institute. The subscription shall be due on the first of November in every year.

37. Members may compound for all annual subscriptions of the current and future years by paying ten guineas.

OTAGO INSTITUTE.

Office-bearers for 1889.—*President*—Dr. de Zouche; *Vice-presidents*—J. C. Thomson, A. Wilson, M.A.; *Hon. Secretary*—Professor Gibbons; *Hon. Treasurer*—E. Melland; *Council*—D. Petrie, M.A., Professor Scott, Dr. Hocken, Rev. H. Belcher, LL.D., Professor Parker, F. R. Chapman, and G. M. Thomson, F.L.S.; *Auditor*—D. Brent, M.A.

Extracts from the Constitution and Rules of the Otago Institute.

2. Any person desiring to join the Society may be elected by ballot, on being proposed in writing at any meeting of the Council or Society by two members, and on payment of the annual subscription of one guinea for the year then current.

5. Members may at any time become life-members by one payment of ten pounds and ten shillings in lieu of future annual subscriptions.

8. An annual general meeting of the members of the Society shall be held in January in each year, at which meeting not less than ten mem-

bers must be present, otherwise the meeting shall be adjourned by the members present from time to time until the requisite number of members is present.

(5.) The session of the Otago Institute shall be during the winter months, from May to October, both inclusive.

WESTLAND INSTITUTE.

OFFICE-BEARERS FOR 1889.—*President*—John Nicholson; *Vice-president*—Arthur H. King; *Treasurer*—J. W. Souter; *Committee*—J. N. Smythe, R. Cross, M. L. Moss, E. B. Sammons, Captain Bignell, J. P. Will, B. Durbridge, F. Eckman, —Scanlan, W. L. Fowler, C. E. Holmes, R. Hilldrup; *Secretary*—Henry Weston.

Extracts from the Rules of the Westland Institute.

3. The Institute shall consist (1) of life-members—*i.e.*, persons who have at any one time made a donation to the Institute of ten pounds ten shillings or upwards, or persons who, in reward of special services rendered to the Institute, have been unanimously elected as such by the Committee or at the general half-yearly meeting; (2) of members who pay two pounds two shillings each year; (3) of members paying smaller sums, not less than ten shillings.

5. The Institute shall hold a half-yearly meeting on the third Monday in the months of December and June.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

OFFICE-BEARERS FOR 1889.—*President*—Dr. Spencer; *Vice-President*—J. Goodall; *Council*—H. Hill, R. C. Harding, L. Lessong, Dr. Moore, A. P. Sheath, J. T. Carr; *Secretary*—A. Hamilton; *Treasurer*—G. T. Fannin; *Auditor*—T. K. Newton.

Extracts from the Rules of the Hawke's Bay Philosophical Institute.

3. The annual subscription for each member shall be one guinea, payable in advance on the first day of January in every year.

4. Members may at any time become life-members by one payment of ten pounds ten shillings in lieu of future annual subscriptions.

(4.) The session of the Hawke's Bay Philosophical Institute shall be during the winter months from May to October, both inclusive; and general meetings shall be held on the second Monday in each of those six months, at 8 p.m.

SOUTHLAND INSTITUTE.

OFFICE-BEARERS FOR 1887.—*President*—Ven. Archdeacon Stocker; *Vice-President*—A. Highton, B.A.; *Council*—Messrs. Bailey, McLean, C. Tanner, Dr. Galbraith, and Dr. Closs; *Treasurer*—E. Robertson; *Secretary*—E. Webber.

NELSON PHILOSOPHICAL SOCIETY.

* OFFICE-BEARERS FOR 1889.—*President*—Bishop of Nelson; *Vice-presidents*—Dr. Boor and A. S. Atkinson; *Secretary*—Dr. Coleman; *Treasurer*—Dr. Hudson; *Council*—Dr. Mackie, J. Holloway, Dr. Cressey, Rev. H. Watson, and R. T. Kingsley; *Curator*—R. T. Kingsley.

Extracts from the Rules of the Nelson Philosophical Society.

4. That members shall be elected by ballot.

6. That the annual subscription shall be one guinea.

7. That the sum of ten guineas may be paid in composition of the annual subscription.

16. That the meetings be held monthly.

23. The papers read before the Society shall be immediately delivered to the Secretary.

TRANSACTIONS

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1888.

I.—BOTANY.

Art. I.—*Further Notes on the* Desmidieæ *of New Zealand, with Descriptions of New Species.*

By W. M. Maskell, F.R.M.S.

[*Read before the Wellington Philosophical Society, 3rd October, 1888.*]

Plates I. to VI.

This paper contains descriptions of several plants to be added to the lists given in my papers of 1880 and 1882, also corrections of some of the identifications in those papers. These corrections are due partly to more complete acquaintance with the writings of foreign authors on the subject, partly to suggestions from Professor Nordstedt, of Lund, Mr. W. B. Turner, of Leeds, and others who have kindly assisted me with advice.

The literature of the *Desmidieæ* is becoming every year more and more voluminous; unhappily, also, it is very scattered. Some works, such as those of Ralfs for England, Wolle for the United States, Delponte for Northern Italy, may be considered as fairly monographic as regards those countries, and are procurable in book-form; but the equally valuable labours of Brébisson, Naegeli, Lundell, Nordstedt, Bennett, Lagerheim, Wille, and many others are to be found chiefly in short papers in Transactions of various societies, and are accessible with great difficulty. Any one who is aware of the extreme minuteness of Desmids, in which sometimes the ten-thousandth of an inch is of importance, and of the delicate variations they exhibit (perhaps an extra crenulation or two on the edge, an extra granule on the frond), will recognise the difficulty of a student of the family in a country like this. Whoever will undertake the preparation of a monograph of the *Desmidieæ* will earn the gratitude of all who care to examine these beautiful little plants.

The following list of the works on the *Desmidieæ* which are now (1888) available to me here is given as a guide to anybody desiring to further investigate the family in New Zealand. They do not form more than a small portion of the whole bibliography of the subject, but are sufficiently comprehensive for most purposes. However, every year is adding to the number of works on Desmids.

De Bary, A. Untersuchungen über die Familie der Conjugaten. 1858.
Bennett, Dr. Fresh-water Algæ of the English Lake District (in "Journ. of Roy. Micros. Soc."). 1886.
Bisset, J. P. List of Desmidieæ found in the Neighbourhood of Lake Windermere (in "Journ. of Roy. Micros. Soc."). 1884.
Delponte, J. B. Specimen Desmidiacearum subalpinarum. 1873.
Ehrenberg, C. G. Die Infusionsthierchen. 1838.
Joshua, W. Burmese Desmidieæ (in "Linn. Soc. Journ."). 1886.
Lagerheim, G. Contributions Algologiques à la Flore de la Suède. 1886.
—— Bidrag till Amerikas Desmidié-Flora. 1885.
—— Ueber einige Algen aus Cuba, Jamaica, und Puerto-Rico. 1887.
—— Ueber Desmidiaceen aus Bengalen. 1887.
—— Sopra Alcune Alghe d'acqua dolce. 1888.
Lundell, P. M. De Desmidiaceis quæ in Suecia inventæ sunt. 1871.
Maskell, W. M. Contributions towards a List of the New Zealand Desmidieæ ("Trans. N.Z. Inst."). 1880.
—— Additions to above Catalogue ("Trans. N.Z. Inst."). 1882.
—— On a New Variety of Desmid ("Trans. N.Z. Inst."). 1885.
—— Note on *Micrasterias americana*, Ralfs, and its Varieties (in "Journ. of Roy. Micros. Soc."). 1887.
Nordstedt, O. Symbolæ ad Floram Brasiliæ centralis cognoscendam—Desmidiaceæ. 1869.
—— Desmidiaceæ ex insulis Spetsbergensis et Beeren Eiland. 1872.
—— Bidrag till Kännedomen om sydligare Norges Desmideer. 1873.
—— Desmidieæ arctoæ. 1875.
—— Desmidieæ et Œdogonieæ in Italia et Tyrolia collectæ. 1876.
—— Nonnullæ Algæ aquæ dulcis Brasilienses. 1877.
—— De Algis aquæ dulcis ex insulis Sandvicensibus. 1878.
—— De Algis nonnullis, præcipue Desmidieis, inter Utricularias Musei Lugduno-Batavi. 1880.
—— Desmidieer samlade af Sv. Berggren under Nordenskioldska expeditionen till Grönland. 1885.
—— Fresh-water Algæ collected by Dr. S. Berggren in New Zealand and Australia. 1887.
Pritchard, A. Infusoria (Desmidieæ by W. Archer). 1861.
Rabenhorst, L. Flora Europæa Algarum aquæ dulcis et submarinæ. 1868.
Ralfs, J. The British Desmidieæ. 1848.
Roy, J., and Bisset, J. P. Note on Japanese Desmids (in "Journ. of Botany," July and August). 1886.
Spencer, Dr. Notes on Fresh-water Algæ ("Trans. N.Z. Inst."). 1881.
—— Continuation of the above. 1882.
Turner, W. B. Notes on Fresh-water Algæ (in the "Naturalist"). 1886.
—— On some New and Rare Desmids ("Journ. of Roy. Micros. Soc."). 1885.
Wallich, Dr. Descriptions of Desmidiaceæ from Lower Bengal (in "Annals and Mag. of Nat. History"). 1860.

WILLS, A. W. On the Desmidieæ of North Wales (in "Midland Naturalist"). 1881.
WOLLE, F. Desmids of the United States. 1884.
—— Fresh-water Algæ of the United States. 1887.

Also detached papers on Desmidieæ and other Algæ by Nordstedt, Wittrock, Marquand, and others.

Professor Nordstedt's paper on the New Zealand *Algæ*, included in the above list, is specially valuable. It contains descriptions, with seven plates, of about one hundred and fifty species and varieties of *Desmidieæ*.

I have to make the following remarks and corrections regarding some of the plants included in my two former papers. These are rendered necessary by more accurate knowledge acquired since 1882, either by observation, or by more extended access to the literature of the subject, or by suggestions from Professor Nordstedt, Mr. Turner, and others.

Aptogonum undulatum ("Trans. N.Z. Inst.," vol. xiii.). The genus *Aptogonum* is now by most writers considered as properly only equivalent to *Desmidium*, Agardh; and Professor Nordstedt attaches my plant as a variety to *D. baileyi*, de Bary. In his description and figures ("Alg. of N.Z.," p. 27, and pl. ii., 8) he does not, I think, express altogether the convex curve of the upper portion of each cell as seen in front-view (or, as I called it in 1880, the "side-view," meaning as in filament). His specimens appear to be more angular than any I have seen, and I have re-examined for comparison a number of preserved specimens and a few fresh ones. Also, he states that in all cases the end-view is "regularly triangular, with rounded angles and almost straight sides." I find that this is so as a rule; but several specimens exhibit an end-view similar to that given in my paper of 1880 (vol. xiii., pl. xi.), except that the printers then added a sort of loop or curved open ring, which was not in my original drawing, and instead of which there should have been only the three small processes near the angles.

Micrasterias rotata (vols. xiii. and xv.). This, which I reported with very great doubt in 1880 and 1882, turns out to be *M. schweinfurthii*, Cohn, a Central African plant. My fig. 16*b* (vol. xv.) is a form of *M. angulosa*, Hantzsch.

Euastrum binale, forma (vol. xiii.). The fig. 26 in pl. xii. is the variety *denticulatum*, Kirchner. See the present paper, with more accurate figure. (Pl. II., fig. 12.)

Holocystis incisa (vol. xiii.). This is *Micrasterias decemdentata*, Naegeli, var. *upsaliensis*, Cleve.

Cosmarium ralfsii (vol. xiii.). This is very near to *C. pseudopachydermum*, Nordstedt ("N.Z. Alg.," p. 53), and is not

the species to which I first referred it. Nordstedt's specimens, most of which seem to have come from the Canterbury District, as mine did, had not the deep incrassation at the ends shown in my pl. xii., fig. 30 (1880). I have re-examined my specimens, and find the incrassation very distinct in most of them, though some are without it.

Cosmarium crenatum (vol. xiii.). This is *C. naegelianum*, Brébisson, var. *latum* of my present paper.

C. undulatum (vol. xiii.) is *C. speciosum*, Lundell. *Vide post.*

C. undulatum, var. β (vol. xv.), appears to me now to be somewhat near *C. impressulum*, Elfving, as figured by Roy and Bisset ("Japan Desm."); but I have not specimens at hand for comparison.

C. margaritiferum (vol. xiii.). The three forms figured by me in 1880 appear to belong to different species. Fig. 27 is probably *C. sublatum*, Nordst.; fig. 28, *C. quaternarium*, Nordst.; and fig. 29, *C. reniforme*, Archer, which is at least very closely allied to *C. margaritiferum*.

C. broomeii (vol. xiii.). This is *C. sublatum*, Nordst.; but I am not able to see the difference between this new species and Lundell's *C. latum*.

C. thwaitesii (?) (vol. xv.) is *Penium cucurbitinum*, var. *subpolymorphum*, Nordst.

C. gemmiferum (vol. xv.) is *C. magnificum*, sp. nov., Nordst.

C. speciosum, var. *inflatum* (vol. xv.). Professor Nordstedt makes this *C. subspeciosum*, var. *validius*, var. nov. In accepting the correction, I cannot help remarking that the differences between *C. speciosum* and *C. subspeciosum* do not appear to be very important.

C. cyclicum, var. *ampliatum* (vol. xv.). In accordance with a suggestion from Professor Nordstedt, I describe and figure this in the present paper as *C. subcyclicum*, sp. nov.

C. tetraophthalmum β *minus* (vol. xv.) is *C. subpunctulatum*, Nordst.

Staurastrum avicula (vol. xiii.) is *S. subdenticulatum*, Nordst.

Staur. (Didymocladon) stella (vols. xiii. and xv.) are forms of *S. sexangulare*, Bulnheim.

Staur. aculeatum (vol. xv.) is *S. splendidum* of the present paper.

Staur. clepsydra (vol. xv.). This name having been previously taken, Professor Nordstedt, at my suggestion, altered it to *S. spencerianum*. He considers the plant a variety of *S.*

connatum, Lundell. Nordstedt observes that the spines in his specimens do not diverge as much as shown in my figures. I have since re-examined my specimens, and find that in the majority the spines, if produced inwards, would meet exactly at the middle of the isthmus, as in my pl. xxiv., fig. 12*a*: a few of them are less divergent, as in my fig. 12*b*.

Docidium dilatatum (vol. xiii.) is *D. ovatum*, Nordst. ("Desm. Brasil."), now attached to the sub-genus *Pleurotænium*. The measurement given in my paper of 1880, "length, $\frac{1}{38}$in.," is a clerical error; it should have been "$\frac{1}{60}$in."

Triploceras tridentatum (vol. xiii.); the same, var. *cylindricum* (vol. xv.); the same, var. *superbum* (vol. xviii.). The distinctions upon which I based this new species and its variations, as separating it from *T. verticillatum* and *T. gracile*, Bailey, from *T. pristidæ*, Hobson, and *T. gracile*, Archer, were the presence of three denticulations on the terminal processes and two tricuspidate projections just below them. Professor Nordstedt considers the last as accidental. On re-examining my specimens of var. *cylindricum* I find that some have the projections, others have not; consequently these cannot be used as sufficient distinction. Nordstedt attaches my var. *superbum* to *T. verticillatum*, and my var. *cylindricum* to *T. gracile*, Bailey; but he says that in neither has he been able to see the terminal processes *tridentate*. In all of the eighteen specimens I have preserved of both, the three teeth are very distinct and clear, although in some which are slightly turned towards the eye the third tooth is seen only foreshortened. There is indeed a marked difference between these two plants and *T. aculeatum* or *T. bidentatum*, Nordst. ("N.Z. Alg.," p. 64), of which I have also specimens. In these last the terminal teeth are never, as far as I have seen, more than two, and sometimes only one is visible. Of the original *T. tridentatum* I have unfortunately no specimens now, and the locality where it was gathered is no longer available. It will be worth while for some one to make a thorough examination of the plants of this genus in New Zealand, for they are very beautiful and worthy of full investigation. On the whole, I venture to maintain my original diagnosis; and, if *T. verticillatum* and *T. gracile* never have three terminal denticulations, I think my plants are rightly separated from both.

The localities in New Zealand where Dr. Berggren collected *Algæ* appear to have been very numerous, ranging from the Bluff to the Bay of Islands. I do not see, however, in the list given in Professor Nordstedt's paper any places in Hawke's Bay or on the south-western coast of the North Island. Most of the new species and varieties mentioned in this present paper and former papers of mine have been collected in these

two regions, either near Napier on the east coast or Otaki on the west. In addition, I have from these places a number of the Desmids described by Nordstedt. The following plants should therefore have habitats attached to them as follows:—

Hawke's Bay.—Sphærozosma excavatum, Cosmarium minutum, Cosm. sexangulare, Cosm. arctoum, Cosm. blyttii, Cosm. repandum, Cosm. pseudopyramidatum, Xanthidium fasciculatum β perornatum, Staurastrum sub-denticulatum, Staur. sebaldi, Staur. sagittarium, Staur. renardi, Penium polymorphum, Closterium brébissonii.

Otaki.—Hyalotheca dissiliens, Hyal. hians, Bambusina borreri, Aptogonum undulatum, Sphærozosma excavatum, Sphær. pulchellum, Phymatodocis nordstedtiana, Onychonema filiforme, Micrasterias decemdontata *var.* upsaliensis, Micr. papillifera, Euastrum ansatum, Eu. longicolle, Eu. cuneatum, Eu. sphyroide, Cosmarium sexangulare, Cosm. arctoum, Cosm. trilobulatum *var.* basichondrum, Cosm. nitidulum, Cosm. (Euastrum) sublobatum, Cosm. punctulatum, Cosm. subpunctulatum, Cosm. obsoletum *var.* punctatum, Cosm. pseudopachydermum, Cosm. turgidum, Cosm. pseudopyramidatum, Cosm. sublatum, Cosm. venustum, Cosm. genuosum, Cosm. quadratum, Cosm. exiguum, Cosm. amœnum *var.* mediolæve, Xanthidium smithii *var.* variabile, Xanth. armatum *var.* basidentatum, Xanth. fasciculatum *var.* perornatum (forma supernumeraria), Xanth. intermedium, Xanth. simplicius, Xanth. dilatatum, Xanth. octonarium, Arthrodesmus incus, Staurastrum muticum, Staur. corniculatum *var.* variabile, Staur. subdenticulatum, Staur. tetracerum, Staur. sexangulare, Staur. sebaldi, Staur. pseudosebaldi, Staur. spencerianum, Staur. dejectum, Staur. sagittarium, Tetmemorus brébissonii, Penium digitus, Pen. margaritaceum, Pen. closterioide, Pen. lamellosum, Pen. polymorphum, Docidium ehrenbergii, Doc. nodosum, Doc. rectum, Triploceras tridentatum *var.* superbum, Tripl. gracile *var.* aculeatum, Tripl. gracile *var.* bidentatum, Spirotænia condensata, Closterium selenæum, Clost. striolatum, Clost. lineatum *var.* sandvicense, Clost. lunula, Clost. gracile, Clost. decorum, Clost. kützingii, Clost. ehrenbergii, Clost. acerosum, Clost. acutum, Clost. intermedium.

My thanks are due to Professor Nordstedt; to Mr. W. Barwell Turner, of Leeds; to Herr G. Lagerheim, of Stockholm; and others, who have kindly assisted me with advice, figures, and specimens; and also to Mr. C. W. Lee, of Otaki, who has been assiduous in forwarding to me gatherings from that place in which occur many of the plants mentioned in these pages.

ADDITIONS TO CATALOGUE OF NEW ZEALAND DESMIDIEÆ.

[NOTE.—Plants marked with an asterisk (*) have been reported by Professor O. Nordstedt, in his account of fresh-water *Algæ* collected in New Zealand by Dr. S. Berggren.]

Genus **Sphærozosma**, Corda.

Sphærozosma compressum, sp. nov. Plate I., fig. 1.

Plant filamentous; joints very minute, elongated, the ends orbicular, the middle cylindrical and compressed, each joint having the appearance of a dumb-bell. Filament twisted, the joints in side-view less compressed in the middle. Section elliptical. Endochrome chiefly visible in the cylindrical portion of each joint. Zygospore smooth, orbicular, a good deal wider than the joints. There are no processes between the joints, of which there are sometimes at least thirty in a filament.

Long. cell., 10·7 μ; lat. term., 5·8 μ; lat. med., 3·5 μ; diam. zyg., 8·8 μ.

Rutherford's Swamp, Otaki.

This plant is allied to *S. excavatum*, Ralfs, but differs in the cylindrical middle, orbicular ends, generally longer and rounder joints, and absence of connecting processes. It seems to be rare.

* *Sphærozosma pulchellum*, Archer. Plate I., fig. 2.

Approximating to *S. bambusinoide*, Wittrock, which Wolle considers as a variety of *S. pulchellum*.

Sphærozosma formosum, sp. nov. Plate I., fig. 3.

Cells almost twice as long as broad; filament not twisted; constriction rather deep, linear within and wide at the mouth; semi-cells roundly inflated at the base, thence sub-cylindrical to the rounded angles of the ends, which are not at all dilated; ends straight or slightly convex; cells joined to each other without any glands or processes. Cytioderm smooth. End-view elliptical or sub-circular.

Long. cell., 22·5 μ; lat., 13·4 μ; crass., 10·5–12 μ.

Hawke's Bay.

Like most species of this genus the filaments are very fragile. I have seen a few with as many as twenty or more joints; but it is rare to find more than three or four cells together, and in most cases the joints are single. When single these cells may easily be taken for *Euastrum sublobatum*, which is nearly of the same size; but in that plant the terminal angles are slightly dilated, the ends are concave, and the end-view is different. *Sphærozosma formosum* is so much larger than *S. pulchellum*, and its cells are so much less inflated (proportionately), that it must for the present be con-

sidered as a separate species. Hereafter it may be perhaps taken only as a large form of *S. pulchellum*.

Genus **Onychonema**, Wallich.

* *Onychonema filiforme*, Ehrenb.

I reported this plant in 1880 under the genus *Sphærozosma*. Messrs. Roy and Bisset ("Japan Desm.," p. 242) draw attention to the fact that the double processes *overlap* the semicells, and that the plant must therefore be placed under *Onychonema*.

Hawke's Bay; Christchurch; Otaki.

Genus **Euastrum**, Ehrenberg.

Euastrum mammatum, sp. nov.

A. *Forma major*, var. *sub-cuneatum*. Plate I., fig. 4.

Frond rather large; constriction deep, somewhat widened internally; segments in front-view cuneate, margins nearly straight, but with a low inflation or mamma about half-way to the end; ends slightly protruding, and at each side of the notch emarginate; the notch is shallow, but seems as if continued in a shallow groove for nearly a quarter of the distance to the isthmus. On the surface of the frond several (seven or eight) very inconspicuous inflations in two transverse series, two of which correspond to the lateral mammæ; at the ends an inflation at each side of the notch. Cytioderm punctate. In side-view, segments tapering from a shallow constriction to narrow rounded ends; median mammæ and inflations visible.

Long., 70–77 μ; lat., 35–42 μ; crass., 18–24 μ; lat. isthmi, 11 μ.

Hawke's Bay.

B. *Forma minor*, var. *ellipticum*. Plate I., fig. 4*a*.

Frond smaller and somewhat less angular than the last; the sides slightly convex, the ends much more protuberant than in *sub-cuneatum*. Lateral mammæ, inflations, and groove as in the larger form. The puncta are less distinct. Ends in side-view very slightly dilated.

Long., 60–67 μ; lat., 31–35 μ; crass., 20–22 μ; lat. isthmi, 12μ.

Rutherford's Swamp, Otaki.

Both forms of this plant approach *E. cuneatum*, Jenner (which also occurs in New Zealand); but they are much smaller, and the inflations, the grooves at the notch, and the protuberant ends distinguish them.

Euastrum sinuosum, Lenormant.

I have two forms which I refer to this species, as follow:—

A. *Forma major*, var. *gemmulosum*, var. nov. Plate I., fig. 5.

Frond rather large; constriction deep, linear; segments in front-view obscurely three-lobed, the basal lobes widely emarginate with very shallow depressions; end-lobe compressed, ends slightly dilated, round, a little protuberant, with a deep narrow notch. At the base of each segment five granuliferous inflations (three on the face and one at each side); above these four others; at the ends an inflation on each side of the notch; altogether eleven inflations on each segment. The granules are conspicuous, and the cytioderm is punctate. Segments in side-view thick, sub-cylindrical, slightly narrowed near the ends, the inflations giving irregular outlines. In end-view the sub-elliptical grooved ends appear conspicuously on the rounded and inflated basal lobes, the granules being conspicuous.

Long., 75–80 μ; lat., 40–44 μ; crass., 26 μ; lat. isthmi, 11·8 μ.

Hawke's Bay; Otaki.

B. *Forma minor*, var. *simplex*, var. nov. Plate I., fig. 6.

Frond much smaller than the last; otherwise similar in outline. Inflations not constant in number: some plants exhibit eleven on each segment, others only seven, the lowest row having only three, the middle only two; inflations granuliferous, the granules distinct. Cytioderm smooth, or, at least, the puncta are extremely obscure. Zygospore globose, with subulate spines which have very broad bases and rather long points.

Long., 53 μ; lat., 26 μ; diam. zyg. ex spin., 27 μ; long. spin., 11 μ.

Rutherford's Swamp, Otaki.

E. sinuosum was attached by Ralfs ("Brit. Desm.," p. 85) to *E. circulare*, Hassell, but has since been considered as separate. The two forms here given do not, as it seems (unless the hitherto undescribed zygospore of the European plant be found to differ), require to be considered as anything but varieties of the type. Nordstedt reports ("N.Z. Alg.," p. 33) *E. sinuosum* from New Zealand without remark. The measurements which he there gives (long., 87 μ; lat., 50 μ) are a good deal larger than those of Ralfs. My var. *gemmulosum* exactly corresponds with Ralfs's dimensions; the var. *simplex* is a good deal smaller. The measurements I give are constant in a number of specimens observed. I think that the conspicuous granules in the inflations of both, the divided sub-elliptical end conspicuous in end-view, and the shallowness of the depressions in the edges, may be taken as sufficiently distinctive characters: the variable number of inflations is not important. Wolle ("Desm. of U.S.," pl. xxvii.) figures *E. circulare* with much-compressed end-lobe, and with a

circular end in end-view. He gives its length as only 36 μ, and does not mention *E. sinuosum*.

* *Euastrum longicolle*, Nordstedt. Plate I., fig. 7.

There is in this plant, near the middle of each segment in front-view, a small circular orifice with a spot in the centre, as if there were there a ring-like opening of the frond. Professor Nordstedt ("N.Z. Alg.," p. 33) casually mentions this feature without further remark. The only other species of this genus, as far as I am aware, exhibiting "scrobiculi" are *E. crassum*, var. *scrobiculatum*, Lundell, and *E. rostratum*, Ralfs, var. *præmorsum*, Nordstedt, the former a Swedish, the latter a New Zealand form.

Rutherford's Swamp, Otaki.

Euastrum rotundum, sp. nov. Plate I., fig. 8.

Frond moderate; constriction deep, linear; segments in front-view obscurely three-lobed, the basal lobes smoothly and widely rounded, not emarginate; on each segment three basal granuliferous inflations, and two others at the ends; a few granules on the edges. Segments in side-view sub-cylindrical at the base, slightly emarginate on account of the median inflation, then tapering rapidly towards the ends, which are very slightly dilated. End-view elliptical with median inflation.

Long., 44·6 μ; lat., 26 μ; crass., 17 μ.

Rutherford's Swamp, Otaki.

Allied apparently to *E. pingue*, Elfving; but it is more slender and less clearly three-lobed. It is much smaller and more evenly rounded than *E. ansatum*, Ralfs. *E. obesum*, Joshua ("Burm. Desm.," p. 638, and pl. xxiii., 19), is like it in outline, but is larger as a rule, and has apparently no granuliferous inflations.

* *Euastrum sublobatum*, Brébisson. Plate I., fig. 9.

Some authors place this plant under *Cosmarium*, others under *Euastrum*. The end-view seems to me to determine its place in the latter genus, and so I leave it.

Hawke's Bay.

Euastrum expansum, sp. nov. Plate I., fig. 10.

Frond very minute, not quite as long as broad; constriction deep, linear, rather wide externally; segments in front-view three-lobed, basal lobes somewhat protruded and a little turned upwards, end-lobe with concave end but without a terminal notch. Frond in side-view narrow, constriction shallow and wide, segments elliptical towards the base and tapering towards the rounded ends. End-view elliptical at the base, with the tip of the end-lobe appearing as if sub-rect-

angular. Inflations doubtful, no specimen having been seen without endochrome.

Long., 11·4 μ; lat., 13·2 μ; crass., 3·2 μ.

Christchurch.

If it were not for the concave ends and for the appearance in end-view, this plant would belong more properly to the genus *Cosmarium*. It is exceedingly minute, and not common.

* *Euastrum denticulatum*, Kirchner. Plate II., fig. 11.

This appears to be one of the innumerable varieties of *E. binale*, Ralfs. It is the plant of which a rough representation was given by me in 1880 ("Trans.," vol. xiii., pl. xii., 26): the present figure is more accurate. Nordstedt ("Alg. of N.Z.," pl. iii., fig. 11) represents this plant as "sp. ad *E. denticulatum* accedens," and in his fig. 9 he shows Kirchner's original type as a good deal smaller. The two sizes occur here together. I can detect only one median inflation on each segment in front-view. The side-view which I give is less "ornate" than that of Nordstedt (iii., 11*c*): it is taken from two specimens observed.

Hawke's Bay; Christchurch.

Euastrum binale, Ralfs, *forma*. Plate II., fig. 12.

This seems to be nearer than the last to the original type, although it does not seem to fit it exactly.

Christchurch.

The variations of *E. binale* would appear to be endless. Ralfs, Lundell, Delponte, Wolle, all give figures which differ a good deal from each other. Especially Wolle describes and figures *E. binale* as distinguished by the "pouting" of the ends at each side of the terminal notch, this very character being a distinctive one of *E. elegans*. In fact, there is so much difference in these figures that one wonders why some of the plants have not been transferred to other species. My figure 12, which I take to be *E. binale* because its ends do not exhibit any "pouting," is very similar to one of Wolle's ("Desm. of U.S.," pl. xxvii., 25) which he names *E. elegans*.

Euastrum undulosum, sp. nov. Plate II., fig. 13.

Frond moderate; constriction deep, linear; segments in front-view trapezoidal, tapering directly from the base to the rather wide ends; sides crenate, each with four equal crenations; ends wide, angles divergent, with minute terminal spines, slightly protuberant towards the middle and emarginate; notch conspicuous; at the base of each segment is a single median conspicuous inflation, and on the face of the frond a number of concentric verrucose undulations. In side-view the constriction is shallow and wide, the inflation visible;

the segments taper with sinuous edges to the rounded ends. End-view sub-elliptical with median inflation. Cytioderm very obscurely punctate, if not free from puncta.

Long., 38·6 μ; lat., 22·7 μ; crass., 13·5 μ.

Hawke's Bay.

E. incrassatum, Nordst., is more elliptical, and has not dilated ends; also its crenations are not equal. *E. crenatum*, Kützing, seems near it; but Dr. Bennett ("Journ. Roy. Micros. Soc.," 1886, p. 9) describes that plant as having quite straight ends and scarcely any notch; also a very shallow constriction. It differs from *E. denticulatum* in the absence of the rather deep notch which in that species separates the terminal from the lateral lobes. In *E. undulosum* the edge is evenly crenulate from the constriction to the terminal angles.

* *Euastrum irregulare*, sp. nov. Plate II., fig. 14.

Frond small; constriction deep, linear; segments in front-view sub-trapezoidal, the sides tapering from the base to the rather wide ends; ends emarginate, with conspicuous notch, the lips of which do not protrude; at the angles fine spines; sides irregularly emarginate, incised with small but distinct depressions, but the division between the terminal and lateral lobes is not clearly marked. Inflations on each segment in front-view seven—three at the base, two at the end, and two near the sides. In side-view the segments are sub-rectangular, slightly inflated towards the base, the ends very slightly dilated, with rounded angles. End-view sub-fusiform, with sinuous edges.

Long., 22·3 μ; lat., 18 μ; crass., 8·9 μ.

Kaitoke; Otaki; Masterton.

In outline this plant is similar to some varieties of *E. binale*, except that the edges are much more irregularly incised; the number and arrangement of the inflations also differentiate it.

Genus **Cosmarium**, Corda.

Cosmarium variabile, sp. nov. Plate II., fig. 15.

Frond moderate, elongated; constriction shallow, rather open; segments tapering from rounded basal angles to rather wide truncate ends; sides sometimes convex, sometimes straight, sometimes concave; ends very slightly rounded or almost straight, never concave, but with often the inner cell-wall distinctly thickened. The cytioderm is not punctate. In side-view segments elliptical, ends more or less acute, sides smooth. The end-view is elliptical.

Long., 42 μ; lat., 21 μ; crass., 15 μ.

Hawke's Bay; Otaki.

The form with *concave* sides approaches to *C. anceps*, Lundell, but it is larger, and the ends are not emarginate. I observe that Wolle's figure of *C. anceps* ("Desm. of U.S.," pl. xviii., fig. 11) differs considerably from Lundell's. The convex form resembles *C. parvulum*, Brébisson, but is also much larger. The three outlines which I give were taken from a gathering in which the plant occurred rather plentifully. Mr. W. B. Turner informs me that he has seen from India a plant something like mine, and thought of giving to it the name of *C. varians*. Herr G. Lagerheim tells me that he has had my plant growing in a greenhouse at Berlin for two years: he does not mention the locality whence he procured it, but this could hardly have been New Zealand.

Cosmarium curtum, var. *attenuatum*, Brébisson. Plate II., fig. 16.

Sufficiently near to the European species, I believe, to permit identification. It will be noticed that this New Zealand form has a slightly elliptical end-view, being narrowed as seen from the side. It is just possible that this may be sufficient to distinguish it from Brébisson's plant, or, at least, to suggest that it should be named "*forma compressa*." But for the present I prefer leaving it as it is, subject to future revision. In dimensions it is rather smaller than the type.

Long., 35 μ; lat., 15 μ; crass., 10 μ.

Otaki.

Cosmarium retusum, Perty; var. *læve*, Roy and Bisset. Plate II., fig. 17.

This plant differs from Perty's type in the total absence of granules. Lundell ("Desm. Suec.," p. 36) remarks that the granules of *C. retusum* are not easily observed; but they are undoubtedly absent in the New Zealand as in the Japanese form.

Long., 17·8 μ; lat., 13·5 μ; crass., 7 μ.

Hawke's Bay; Otaki.

The dimensions given are rather smaller than those of Roy and Bisset ("Japan Desm.," p. 195), but the plant seems to be otherwise identical.

Cosmarium pachydermum, Lundell, *forma intermedia*. Plate II., fig. 18.

Long., 81 μ; lat., 55 μ; crass., 19 μ.

Christchurch; Hawke's Bay; Kaitoke; Otaki.

This plant seems to be intermediate in size between Lundell's original type and Nordstedt's "var. *minus*" ("Norges Desm.," p. 18). The segments are quite round, as in the type; but in side-view they are rather narrower and more attenuated.

The plant which I reported as "*Cos. ralfsii*, var. *β*" ("Trans.," 1882, vol. xv., p. 239), may perhaps have been a still smaller form of the same plant; but I have not now any specimens to which to refer.

* *Cosmarium trilobulatum*, Reinsch, var. *basichondrum*, Nordstedt. Plate II., fig. 19.

Long., 18 μ; lat., 12 μ.

Otaki.

My measurements are a little less than those given by Professor Nordstedt ("Alg. of N.Z.," p. 57).

Cosmarium cordanum, Brébisson, *forma minor*. Plate II., fig. 20.

Long., 30 μ; lat., 15 μ; crass., 12 μ.

Rutherford's Swamp, Otaki.

I have never seen the original figures of this plant, and have judged from those given of it by Wolle ("Fresh. Alg. of U.S.," pl. lx.) and by Turner ("Journ. Roy. Micr. Soc.," Dec., 1885). With these it agrees nearly in all but size, and perhaps a little more angular form in side-view.

* *Cosmarium repandum*, Nordstedt. Plate II., fig. 21.

I think my specimens have rather more sinuous sides than the type.

Cosmarium speciosum, Lundell, *forma genuina*. Plate II., fig. 22.

Long., 50 μ; lat., 26·8 μ; crass., 17 μ.

Hawke's Bay.

The dimensions of this plant seem to vary. Wolle says that the American forms are much larger than the Swedish.

Cosmarium speciosum, Lundell, var. *simplex*, Nordstedt. Plate II., fig. 23.

Long., 40–45 μ; lat., 28–32 μ; crass., 15–17 μ.

Hawke's Bay.

This plant is less angular than the type; but I scarcely like to consider it at present as a new variety. Hereafter it may be separated on account of its rounder form.*

* *Cosmarium sub-speciosum*, var. *validius*, Nordstedt. Plate II., fig. 24.

This plant, in vol. xv. of our "Transactions," I reported as *C. speciosum*, var. *inflatum*. Professor Nordstedt has placed it more correctly as above.

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* Since completing this paper I have received from Dr. Nordstedt a tracing of *C. speciosum*, *forma intermedia*, Wille ("Desm. of Nov. Zemlya"), which appears to be perhaps nearer our plant than the var. *simplex*.

Cosmarium regnesi, Reinsch, var. *ornatum*, var. nov. Plate II., fig. 25.

Frond very minute; constriction shallow, wide, and curvilinear; segments in front-view irregular, sides very short, cut into three minute lobules with concave edges; angles between the lobules sharp; ends concave. Cytioderm bearing at each side of each segment three granules arranged triangularly. Segments in side-view sub-fusiform, tapering gradually to rounded ends; two minute granules visible on the face and two others on each edge: of the last, one pair are near the base, the other near the end. End-view angular-elliptical, a minute granule marking each quasi-angle.

Long., 9 μ; lat., 9 μ; crass., 2·5 μ.

Christchurch.

If I may judge by a tracing sent to me by Mr. W. B. Turner of Reinsch's original figure of this plant, and by a figure of Mr. Turner's in the "Naturalist," February, 1886, the plant herein described is more ornate than the original. Some specimens, however, in slides sent me from England a few years ago by Mr. Joshua, are nearer to this New Zealand form, though not exactly similar. Reinsch's figure is, as I understand, by no means a good one. The plant is exceedingly minute, and is scarcely to be made out with a less power than 1,000 diameters. It appears to have sometimes a pink tinge.

Cosmarium holmiense, Lundell, *forma minor*. Plate III., fig. 26.

Long., 54 μ; lat., 35 μ; crass., 23·7 μ.

Hawke's Bay.

Shorter, and not quite as wide as the original type. The American form (Wolle, "Desm. of U.S.," p. 68) is even narrower. The dimensions here given are constant in many specimens.

Cosmarium naegelianum, Brébisson, var. *latum*, var. nov. Plate III., fig. 27.

Frond small; constriction deep, linear, narrowed at the mouth; segments in front-view nearly twice as wide as long, with slightly convergent sides; edges crenulate, with five crenations at each side; ends wide, plane, or very obscurely crenulated. In side-view, segments sub-rectangular, angles rounded; in end-view elliptical, with a very slight median inflation and an obscurely crenulate edge. Cytioderm minutely punctate, the puncta obscurely arranged in transverse rows when in side-view. Zygospore globose, spinous with short sharp subulate spines.

Long., 25 μ; lat., 23·8 μ; crass., 11 μ; diam. zygosp. incl. spin., 32·7 μ; long. spin., 3 μ.

Christchurch; Hawke's Bay; Otaki.

A plant of the series of *C. crenatum*, Ralfs; but proportionately shorter and broader, and the crenulations of the ends in front-view are so obscure that the end often appears nearly straight. *C. naegelianum*, as figured by Wolle ("Desm. of U.S."), is narrower than this New Zealand form, but his description otherwise corresponds. This plant differs from *C. sub-punctulatum*, Nordstedt ("Alg. of N.Z.," p. 47), in the absence of the granules which are conspicuous in that form. The zygospore is new.

Cosmarium turnerianum, sp. nov. Plate III., fig. 28.

Frond moderate; segments in front-view twice as broad as long, or more; constriction deep, linear, and somewhat wide, so that the segments do not closely approximate; segments sometimes circular, sometimes trapezoidal, the edges deeply sinuous with ten wide crenulations; cytioderm marked by a number of granular inflations corresponding to the crenulations of the edge, giving an appearance to the frond of grooves radiating from the centre; in the median space a series of seven smaller inflations in a row on the base of each segment. A frond with circular segments is almost regularly elliptical, the ends at the constriction somewhat sharp. In side-view, segments sub-elliptical, narrow, ends rounded, edges very obscurely crenulated towards the ends, and with a slight inflation towards the base marked with minute inflations. In end-view, frond sub-elliptical with sharp ends, the thickness variable; a slight median inflation visible, and the granules arranged in transverse series.

Long., 36–40 μ; lat., 40 μ; crass., 14–20 μ.

Hawke's Bay.

This plant approaches *C. cyclicum*, Lundell, especially when elliptical with rounded segments, but it is smaller, has a wider sinus at the constriction, with more conspicuous "grooves" on the frond, and the row of granules at the base of each segment, producing the inflation in side-view, is quite distinctive. Lundell gives two variant figures of *C. cyclicum*, neither of which has trapezoidal segments. *C. cyclicum*, var. *arcticum*, Nordstedt, is more angular than Lundell's type, but its edges are irregularly incised, and it has not the rows of granules which produce the inflations of our species.

I have ventured to attach to this plant the name of Mr. W. B. Turner, who has been kind enough to give me much help.

Cosmarium sub-cyclicum, sp. nov. Plate III., fig. 29.

In 1882 ("Trans." vol. xv., p. 241) I reported this plant under the name *C. cyclicum* var. *ampliatum*. Professor Nordstedt suggests to me that it should rather be a new species,

and certainly the number of small crenulations on the margin is about double that of Lundell's plant, which has only twelve. The rather widely-gaping constriction (from which I took my former name) seems to separate it from any species hitherto described.

Long., 51 μ; lat., 46–49 μ; crass., 16 μ.

Sumner Road, Lyttelton.

Cosmarium heliosporum, sp. nov. Plate III., fig. 30.

Frond small; segments in front-view sub-quadrate, crenate, with from ten to twelve conspicuous crenations; angles rounded; cytioderm marked with large granular inflations corresponding to the crenations and radiating from the median space, giving the frond a deeply-grooved appearance; in the median space, at the base of each segment, a row of small, apparently vertical inflations, usually five in each row. In side-view, segments sub-quadrate, slightly tapering to the wide ends, which are a little convex; edges smooth at the base of the segments, and minutely crenulate at the ends. End-view elliptical, with transverse rows of granules; viewed from the base of a segment the granules form a circle round the isthmus. Zygospore globose, with numerous spines; the spines subulate, on broad bases, and minutely divided at the apex.

Long., 28·3 μ; lat., 23 μ; crass., 15·6 μ; diam. zygosp. exclus. spin., 33 μ; long. spin., 3·5 μ.

Hawke's Bay.

A species belonging to the series of *C. crenatum*, but distinct by its sub-quadrate segments, which are conspicuously crenate at the ends, and by the form and size of the spines on the zygospore. From these spines Mr. Turner suggested to me the specific name which I have herein adopted.

* *Cosmarium amplum*, Nordstedt. Plate III., fig. 31.

I give a figure of this plant, partly because of its peculiar end-view in some cases (roundly triangular); partly because the granules seem to me often to be arranged in concentric curves, and not always in quincunx, as Professor Nordstedt reports; and partly on account of a conspicuous inflation observed in some specimens when viewed neither in front nor directly from the end. The plant is a fine one. Perhaps two-thirds of the specimens observed by me from Otaki have a triangular end-view; all those from Hawke's Bay have elliptical ends.

Hawke's Bay; Otaki.

Cosmarium quadrifarium, Lundell, var. *gemmulatum*, var. nov. Plate III., fig. 32.

Frond moderate; constriction deep, linear; segments in

front-view sub-semicircular, basal angles slightly rounded; edges incised with numerous (eighteen to twenty on each) crenulations, of which the little elevations are truncate; cytioderm apparently slightly grooved just within the edge; in the centre of each segment a circular granuliferous inflation, the granules arranged more or less concentrically, and connected by a network of fine rays; between the inflation and the edge are three concentric rows of granules. End-view elliptical, the edges crenulate, the median inflation conspicuous, sub-orbicular; on the surface are six rows of granules, arranged longitudinally.

Long., 50μ; lat., 33–36 μ; crass., 18 μ ex. inflat.

Rutherford's Swamp, Otaki.

This handsome plant is apparently an intermediate form between the original *C. quadrifarium* and its varieties *hexastichum*, Lundell, and *octastichum*, Nordstedt. From the former it differs in having six rows of granules in end-view instead of four, and from the two latter in having the granules on the median inflation arranged more or less concentrically instead of in direct rows. The network of rays connecting these granules appears to be a character visible in the var. *octastichum*. The edges in end-view in my specimens do not exhibit such conspicuous "papillæ" as those figured by Lundell and Wolle, but have obscure crenulations. I have not seen the zygospore, which in *C. quadrifarium* is quadrate, a rather unusual form amongst *Cosmaria*.

Genus **Xanthidium**, Ehrenberg.

Xanthidium intermedium, sp. nov. Plate IV., fig. 33.

Frond large; constriction deep, linear; segments in front-view sub-trapezoidal, widely and roundly inflated at the base, then tapering and slightly concave towards the ends, which are wide and straight, the angles very slightly dilated. Cytioderm punctate. On each segment are a number of strong simple spines, neither dilated nor forked: most of these are disposed in groups on the edges of the basal inflations in front-view, others in pairs or in threes on the ends and at the terminal angles, a few are scattered or in short rows on the surface. Median inflation not to be made out in front-view; granules none. End-view elliptical, with a very slight median inflation; the spines arranged in a longitudinal band, most numerous towards the two ends, and with a parallel row of only a few spines at each side of the band.

Long., 89 μ; lat., 71·5 μ; crass., 35·5 μ; long. spin., 4·5 μ.

Rutherford's Swamp, Otaki.

The main distinction, it would seem, between the genera *Cosmarium* and *Xanthidium* lies in the usually truncate and granular projection which, in addition to the spines, occupies

the centre of each segment. In the present plant this projection is so slight, so round, and so free from granules that the generic position of the plant is not easily fixed. In a general way it belongs probably to the series of *X. aculeatum*, Ehrenberg, but it is not that species. It is smaller than *X. octonarium*, Nordstedt (also a New Zealand plant), and has many more spines. Hereafter it may be found necessary to relegate it to the genus *Cosmarium*, but even then it will have to occupy a rather doubtful position, something like Mohammed's coffin.

Genus **Arthrodesmus**, Ehrenberg.

Arthrodesmus convergens, Ehrenb., var. *divaricatus*, var. nov. Plate IV., fig. 34.

Frond resembling generally the original type, with the segments in front-view elliptical, though the edges are usually very slightly angular (so slightly as not to form a distinctive character). The spines converge at first and then diverge in a regular curve, and they are blunt, if not even a little dilated, at the tip. In end-view the spines are straight.

Long., 36 μ; lat., 33·5 μ; crass., 13 μ; long. spin., 8 μ.

Hawke's Bay; Otaki.

I mentioned this plant in my paper of 1882 ("Trans.," vol. xv., p. 243), but, as I had at that time only seen one specimen, did not think it desirable to found a variety on it. Since then, however, I have obtained a number of specimens, all agreeing in the above characters, and venture therefore to consider them as not exactly conforming to the type. I have seen two or three specimens of larger size, reaching long. 56 μ, lat. 45 μ.

Arthrodesmus incus, Brébisson.

Besides the forms *a*, *c*, *d* of Ralfs ("Brit. Desm.," pl. xx.), reported by Professor Nordstedt ("N.Z. Alg.," p. 45), I have specimens of the form *b* from Otaki. The plant is very variable in shape, and seemingly also in size.

Genus **Staurastrum**, Meyen.

Staurastrum dilatatum, Ehrenberg, *forma*. Plate IV., fig. 35.

Frond small; constriction deep and wide; segments in front-view elliptical, in end-view triangular, with slightly concave sides and widely-rounded angles; cytioderm punctate.

Long., 30–35 μ; lat., 34–41 μ.

Christchurch; Hawke's Bay; Otaki; Wellington.

Professor Nordstedt reports a form, *S. dilatatum*, var. *obtusilobum*, De Notaris, from New Zealand, but with four-angled end-view. All the specimens I have observed have but three angles.

Staurastrum bieneanum, Rabenhorst, *forma minor*. Plate IV., fig. 36.

Frond small; segments in front-view fusiform, with very wide constriction; in end-view triangular, with deeply concave sides, and rounded, rather tapering, angles; cytioderm punctate, the puncta in transverse lines; edges apparently not perfectly smooth.

Long., 20–25 μ; lat., 15–22 μ.

Hawke's Bay; Wellington; Otaki.

I prefer attaching this plant to Rabenhorst's species (which, indeed, he considered rather a variety of *S. orbiculare*, but which later authors have considered distinct), instead of erecting it into a separate species on the minute variations which it presents.

Staurastrum sub-amœnum, sp. nov. Plate IV., fig. 37.

Frond small, slightly variable in size; constriction only a minute notch. Segments in front-view unequally pentagonal, the sides obscurely sinuous and widening from the base to the sub-acute lateral angles, thence tapering rapidly to the terminal angles; ends straight. The edges all round are obscurely irregular. Within the border the edges of the side-view can be seen. Cytioderm punctate; puncta in concentric curves. In side-view the segments are lozenge-shaped, the angles slightly truncate; edge irregular; puncta in longitudinal series, and the edge of the front-view is visible. In end-view the frond is four-sided, the angles slightly truncate, sides slightly concave, puncta transverse.

Long., 35–39 μ; lat., 28–33 μ.

Hawke's Bay.

This plant belongs to the series of *S. capitulum*, Brébisson, and *S. amœnum*, Hilse, of which Professor Nordstedt reports a variety, "*tumidiusculum*," from New Zealand. It is, however, less *ornate* than any of these, and also smaller. *S. meriani*, Reinsch (as figured by Wolle, "Desm. of U.S.") also approaches it.

Staurastrum alternans, Brébisson, var. *sub-alternans*, var. nov. Plate IV., fig. 38.

Frond small; segments in front-view sub-elliptical; when viewed slightly tilted (as in the figure) the third angles of the two segments are not exactly opposite. In end-view, segments triangular, sides concave, angles rounded; the frond being only slightly twisted, the angles of each segment are neither quite in correspondence nor quite alternate. Cytioderm punctate, the puncta transverse.

Long., 25 μ; lat., 26·7 μ.

Christchurch; Hawke's Bay.

I have proposed this as a true "variety" of the original form, as in all the specimens seen since 1879 (perhaps more than a hundred) the twisting of the frond, although distinct, is never sufficient to bring the angles in end-view regularly alternate as in the European and American types.

Staurastrum striolatum, Naegeli, var. *acutius*, var. nov. Plate IV., fig. 39.

Angles, both in front- and end-views, a good deal sharper than in the type.

Long., 21 μ; lat., 23 μ.

Hawke's Bay.

Staurastrum ventricosum, sp. nov. Plate IV., fig. 40.

Frond moderate; constriction deep and wide; segments in front view elliptico-fusiform, with convex ends, and prolonged into short processes each tipped with three minute spines; cytioderm rough with conspicuous granules; on the outer edges several spines, small, simple, neither dilated nor forked. End-view triangular; processes short; edges obscurely irregular; sides slightly concave; granules in transverse series.

Long., 39 μ; lat., 40 μ.

Christchurch; Wellington; Kaitoke; Hawke's Bay.

A plant which I had at first considered as a variety of *S. proboscideum*, Brébisson; but it is separated from that species by the absence of forked or dilated spines, and by the transverse arrangement of the granules in end-view. It is much smaller than the next species, and has not concave or depressed ends with widely divergent spines in front-view.

Staurastrum splendidum, sp. nov. Plate IV., fig. 41.

Frond rather large; constriction wide. Segments in front-view sub-orbicular, the ends depressed or sometimes slightly concave, sides produced into moderately long processes, each bearing three conspicuous spines. Cytioderm rough with large conspicuous granules. Edge smooth, or obscurely irregular for a little way from the isthmus, thence conspicuously crenulated to the commencement of the depressed ends; between the crenulations conspicuous simple spines inclined outwards. End-view triangular; cytioderm rough with granules arranged transversely; sides slightly concave; edges crenulate, with simple spines; angles truncate, tricuspid; viewed from the isthmus the orbicular form of the segment is conspicuous.

Long., 67 μ; lat., 52 μ.

Christchurch; Hawke's Bay.

This is the plant which in my paper of 1882 I wrongly considered as a form of *S. aculeatum*, Ehr. Mr. W. B. Turner tells me that he thinks it is intermediate between the smaller

forms of *S. sebaldi*, Reinsch, and *S. proboscideum*, Brébisson. The large, simple spines, and the straight or concave ends, seem to separate it from either; and the spines are not sufficiently long nor the segments slender enough for *S. aculeatum.* The two forms reported from New Zealand by Professor Nordstedt—*S. sebaldi*, *β ornatum*, var. *novizelandica*; and *S. pseudosebaldi*, var. *tonsum*—differ from it in several particulars, both being much more slender, and the last not having a triangular end-view. The large size, the depressed ends, and the conspicuous spines on the edge in end-view distinguish it from the last species.

Staurastrum pileatum, Delponte, var. *inflatum*, var. nov. Plate IV., fig. 42.

Frond moderate; constriction shallow and wide. Segments in front-view sub-trapezoidal, widest outwardly; sides and ends slightly convex; outer angles terminated by two rather thick spines; cytioderm smooth or very obscurely punctate in the middle, and bearing five or six transverse rows of granules towards the angles; edges obscurely irregular. End-view triangular; sides very slightly concave, angles slightly inflated and terminating in spines; granules in transverse rows near the angles only; edges smooth except by the rows of granules.

Long., 45 μ; lat., 60 μ.

Otaki.

This plant appears to differ from Delponte's species ("Desm. Subalpin.," p. 167) in the more convex form both in front- and side-views.

Staurastrum pseudoligacanthum, sp. nov. Plate V., fig. 43.

Frond moderate; constriction deep, linear; segments in front-view sub-quadrate, but produced at the sides to subacute angles so as to have an irregularly pentagonal form; sides sinuous, ends straight; cytioderm smooth in the median space, and bearing towards the angles a few transverse rows of minute puncta; edges obscurely irregular or crenulate, and bearing between the lateral angles and the straight ends four or five spines, of which two at each side are conspicuous; the spines of the third angle are visible on the face of the frond. End-view triangular; sides straight, edges obscurely irregular; on each side are two spines dividing it in three equal divisions; cytioderm bearing transverse rows of puncta towards the angles, and three pairs of granules corresponding to the six marginal spines.

Long., 35·9 μ; lat., 37·9 μ.

Otaki.

The figure of *S. oligacanthum*, Bréb., given by Nordstedt ("Desm. Arctoæ," pl. vi.), differs from the above in a few

particulars, mainly in the arrangement of the spines. The triangular end-view of our species is scarcely a distinctive character, as so many of the *Staurastra* seem to have indifferently three or four sides.

Staurastrum spinuliferum, sp. nov. Plate V., fig. 44.

Frond moderate; constriction shallow, wide; segments in end-view inflato-fusiform, widening rapidly from the isthmus to the angles; ends convex; angles acute; cytioderm bearing minute puncta arranged in transverse rows, and towards the angles very minute spines; many very minute spines along the edges all round, and at each angle three spines rather larger. End-view triangular; sides straight or slightly concave; cytioderm punctate; spines as in front-view.

Long., 34 μ; lat., 26·9 μ.

Hawke's Bay.

Probably of the series of which *S. hirsutum*, Ehr., is the type; but it differs in its acutely-angled front-view from all, and the spines are also much smaller than in any species described. Indeed, only careful examination will detect them. I have stated above that in front-view these spines are noticeable on the surface towards the angles, the median space being simply punctate: it may be that the spines cover the whole frond, but they are too minute to be made out. Mr. Turner suggests that the plant may be a form of *S. kjellmanni*, Wille, which has minute conical granules on the edge; but in our species they are certainly fine spines.

Staurastrum pseudassurgens, sp. nov. Plate V., fig. 45.

Segments in front view widely dilated from a rather narrow isthmus, with gaping constriction; lower edges very slightly crenulate, outer edge crenulate, convex, with a series of minute granular verrucæ just within the edge; segments produced at each side into sub-cylindrical processes, each of which curves gradually but conspicuously upwards, and ends in two rather large teeth, widely diverging, one tooth turned well upwards, the other usually horizontal or nearly so. End-view fusiform, slender, the median portion slightly dilated, the rows of verrucæ visible; two terminal teeth usually visible, but often only one. Zygospore sub-globose with concave edges, bearing a number of long rays which are forked and recurved at the apex.

Long., 29–32 μ; lat., 46–50 μ; diam. zyg. ex rad., 27 μ; long. rad., 12 μ.

Rutherford's Swamp, Otaki.

I at first considered this plant as *S. assurgens*, Nordstedt, having then only a sketch of the latter. I find, however, that it differs, first in size, secondly in less slender shape, thirdly in never exhibiting more than two teeth on each process. In

general appearance it approaches *S. bicorne*, Hauptfleisch (*apud* Lagerheim *in lit. cum icone*); but that plant has deep quadrangular crenulations on the edge in front-view, which are absent from our species. The zygospore resembles somewhat that of *S. sagittarium*, Ndst. ("Alg. of N.Z.," p. 37), but is much smaller and less angular.

Staurastrum inconspicuum, Nordstedt, *forma gracilior*. Plate V., fig. 46.

Frond very minute; in front-view sub-rectangular, the constriction represented by concave sides, and the angles produced into short sub-cylindrical processes slightly bent in the middle and obscurely forked at the tip; two of these processes can be seen in focus at once at each end, and a third is seen either in front or behind, between each pair. End-view convexo-triangular, the angles produced in processes alternating with the three processes of the other end, which may be seen between them. Length of the frond in front-view more than twice the diameter at the isthmus.

Long. ex rad., 11·7 μ; lat., 9 μ; lat. isthmi, 4·3 μ; long. rad., 4 μ.

Otaki.

This form is more slender than Nordstedt's original plant, and rather smaller; and the specimens which I have observed are triangular in end-view, the American and European forms being quadrangular. Probably forms may exist here with either three or four sides.

Staurastrum furcatum, Ehrenberg, *forma?* Plate V., fig. 47.

I have only one specimen of this plant, and have not seen it in end-view: it is referred therefore here only provisionally to Ehrenberg's species. It is the one which in my paper of 1882 I considered as probably *S. spinosum* of Ralfs, which several authors (*e.g.*, Rabenhorst and Wolle) refer to *S. furcatum*. The species appears to be very variable: my figure approaches that of Wolle ("Desm. of U.S.," pl. xlviii.), especially in the occurrence of a process or processes on the frond near the isthmus.

Long. ex rad., 26·7 μ; lat., 16·4 μ; long. rad. circ., 5·5 μ.

Hawke's Bay.

Staurastrum brachiatum, Ralfs, var. *gracilius*, var. nov. Plate V., fig. 48.

Frond extremely minute; constriction only a small notch; segments in front-view sub-quadrate, produced at the outer angles into long, sub-cylindrical, smooth, very transparent processes, which are deeply cut into two or three (mostly three) points; endochrome extending only to the quadrate

portion of the segment; a third process is visible either in front or behind at each end. In end-view triangular, the sides slightly convex, angles produced into long processes, and the three processes of the other end are visible alternating with these. The plant has a distinct mucous envelope.

Long. ex rad., 7·5 μ; lat., 5 μ; long. rad., 6 μ, ex spin.

Rutherford's Swamp, Otaki.

The great transparency of the rays and the minuteness of this plant render it difficult to examine it properly. I am not quite sure that the rays may not perhaps be very slightly rough-edged. I have attached it to *S. brachiatum*, although it is scarcely a third of the size of that plant, and its rays are more slender and rather more sharply pointed. It has also a resemblance to *S. levispinum*, Bisset ("Desm. Winderm."), but that also is much larger, and its rays do not appear to be forked. The distinct mucous envelope of our plant is not, I suppose, a specific character.

* *Staurastrum spencerianum.*

This plant, reported by me in 1882 under the name *S. clepsydra*, is considered by Nordstedt as a sub-species of *S. connatum*, Lundell. The name has to be changed, as that of "*clepsydra*" had been previously taken.

Genus **Tetmemorus**, Ralfs.

Tetmemorus granulatus, Brébisson, *forma minor*. Plate V., fig. 49.

I attach this plant to this species, instead of to *T. lævis* (also occurring in New Zealand), as its form is the same on all sides and it has the lip-like process of the type.

Long., 130–150 μ; lat., 30–35 μ.

Otaki.

* *Tetmemorus brébissonii*, Ralfs.

Specimens of this plant from Otaki, where it is fairly plentiful, in company with the last species, do not show the tapering of the ends from which Professor Nordstedt has established his New Zealand variety, *attenuatus*.

Genus **Penium**, Brébisson.

* *Penium cucurbitinum*, Bisset, var. *sub-polymorphum*, Nordstedt. Plate V., fig. 50.

Long., 75 μ; lat., 37 μ.

Christchurch; Hawke's Bay; Otaki.

Professor Nordstedt establishes his variety only on account of the fact that the zygospore of the European plant has not been yet discovered. He figures the zygospore of our New Zealand form as quadrate: I have not seen it.

Penium polymorphum, Perty, *forma*. Plate V., fig. 51.

The semi-cells are more cylindrical than in the type, as figured by Lundell ("Desm. Suec.," pl. v., 10), and the ends less attenuated. The striæ are so faint that it is very difficult to make them out. The cytioderm is pale pink or straw-coloured.

Long., 43 μ; lat., 20 μ.

Christchurch; Hawke's Bay; Otaki.

My measurements, which are much smaller than those of Professor Nordstedt, agree exactly with those of Lundell.

Penium navicula, Brébisson. Plate V., fig. 51*a*.

Long., 55-60 μ; lat., 12–15 μ; diam. zyg., 20–25 μ; diam. zyg. diagonal, 45 μ.

Rutherford's Swamp, Otaki.

This plant ought perhaps to be considered as a small form of *P. closterioide*, Ralfs, but Wolle and others separate it. I cannot detect any "dancing" granules at the ends, as the characteristic ones of *P. closterioide*. I give a figure of the zygospore (of which I have observed two specimens), which Wolle ("Desm. of U.S.," p. 36) describes without figuring. A figure of it is given in Lundell ("Desm. Suec.," pl. v., 8), and the dimensions of that are not far removed from ours; but the angles appear to be somewhat sharper, and the empty conjugating cells proportionately smaller than those of the specimens which I have seen.

Penium incrassatum, sp. nov.(?). Plate V., fig. 52.

Frond sub-elliptical, somewhat dilated at the middle, the ends broadly rounded; there is no constriction, but the cell-wall appears slightly thickened outwardly at the centre, so that in some specimens there is the appearance of a thin ring round the plant. Cytioderm very obscurely punctate.

There are two sizes—*Forma major*, long. 60 μ, lat. 38 μ; *Forma minor*, long. 40 μ, lat. 25 μ.

Hawke's Bay.

On account of the thickening of the cell-wall in this plant I hesitate as to its position. It seems to be properly attached to the genus *Penium* by the arrangement of the endochrome in fillets, and if there were any sign of a median constriction I should look upon it as perhaps allied to *P. lagenaroide*, Bisset ("Desm. Winderm."). The name given above is applied to it here provisionally.

Genus **Docidium**, Brébisson.

* *Docidium nodosum*, Bailey. Plate V., fig. 53.

Long., 250 μ; lat. max. nod., 41·5 μ.

Rutherford's Swamp, Otaki.

* *Docidium ovatum*, Nordstedt.

In my paper of 1880 I reported this species under the name of *D. dilatatum*. I had not then seen Professor Nordstedt's Brazilian plant, identical with it. But a clerical error crept into my description of it, as the length was given as $\frac{1}{65}$in.: this should have been $\frac{1}{65}$in. The dimensions are, in point of fact, somewhat variable. Long., 340–380 μ; lat., 85–96 μ.

Mr. Turner thinks that our New Zealand plant differs a little from the Brazilian, and in several specimens I can observe differences in the granules at the ends; but probably these distinctions are not important.

Docidium ovatum, Nordstedt, var. *tumidum*, var. nov. Plate VI., fig. 54.

Frond large, stout, tumid-cylindrical; constriction rather wide and deep; segments regularly ovate, with smooth edges, and tapering without dilatation to the somewhat wide ends, which bear conspicuous small tubercles, the tubercles not set close together. Cytioderm punctate.

Long., 250 μ; lat. max., 112 μ; lat. constric., 58 μ; lat. term., 27 μ.

Rutherford's Swamp, Otaki.

A form clearly distinguishable from the last, being much shorter and proportionately broader; and the tubercles at the ends are more conspicuous and wider apart.

Genus **Closterium**, Nitzsch.

Closterium dianæ, Ehrenberg, var. *arcuatum*, Bréb. Plate VI., fig. 55.

The dimensions of this plant vary considerably. The largest specimens I have seen reach as much as 530 μ (chord of arc); the smallest are no more than 175 μ. In the largest the ends are slightly emarginate, as shown in fig. 55*b*, and faint transverse striæ can be made out in the middle (fig. 55*c*). I think the more semicircular, or genuine, form of *C. dianæ* does not occur here.

* *C. venus*, Kützing. Plate VI., fig. 56.

This is also variable in size, ranging from 114 μ in length down to 67 μ (chord of arc). I should take this to be only a small form of *C. dianæ*, but there may be something in the distinction made by Delponte ("Desm. Subalp.," pls. xvii. and xviii.) that in *C. dianæ* the ends are emarginate, in *C. venus* simply tapering.

* *C. cynthia*, de Notaris, *forma*. Plate VI., fig. 57.

The striæ are excessively faint, and the ends thicker than in the type. The plant would approach very closely to

C. jenneri, Ralfs, if the frond ever showed any constriction in the middle; but I can detect none.

Long. chord, 78·5 μ; lat., 9 μ.

Christchurch; Otaki; Kaitoke.

Closterium decorum, Brébisson, *forma gracilior*. Plate VI., fig. 58.

The frond is more slender than the type (as given by Delponte and Wolle), and the outer edge is often slightly depressed towards the middle, giving a wavy appearance to the plant. The dimensions vary a good deal.

Long., 196–230 μ; lat., 13·5–24·5 μ.

Christchurch; Kaitoke; Wellington; Otaki.

* *Closterium prælongum*, Brébisson. Plate VI., fig. 59.

The ends are slightly recurved in all the specimens which I have seen.

Long., 204 μ; lat., 24 μ.

Kaitoke.

* *Closterium lineatum*, Ehrenberg, var. *sandvicense*, Nordstedt. Plate VI., fig. 60.

As the striæ are very closely set in this plant, and the inner edge frequently a good deal inflated, I attach it to Professor Nordstedt's form, which he reports from the Sandwich Islands. It is a little smaller, apparently, than that type.

Long., 460–570 μ; lat., 30–40 μ.

Hawke's Bay; Otaki.

Closterium (?) or *Raphidium* (?). Plate VI., fig. 61.

Frond very long, slender, and acicular; the ends tapering to very sharp points. Viewed in one direction it is quite straight; in another the outer edge is slightly convex, the inner almost straight for two-thirds of its length from the middle, then slightly bent. Endochrome extending only to the bend of the inner edge, the rest to the ends translucent; vesicles in a single row; at the middle there is a minute clear space which can be seen to extend across the whole width. Cytioderm not striated. Near the ends are vacuoles with "dancing" granules.

Long., 350–380 μ; lat., 10 μ.

Wellington.

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[NOTE.—Excepting where otherwise mentioned, all the forms in this list are magnified 700 diameters.]

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Fig. 3. *S. formosum*, n. sp.

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Fig. 4A. *E. mammatum*, var. *ellipticum*, n. sp. et var.
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PLATE II.

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Fig. 17. *C. retusum*, Perty, var. *læve*, Roy and Bisset.
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Fig. 23. *C. speciosum*, Lundell, var. *simplex*, Nordstedt.
Fig. 24. *C. sub-speciosum*, var. *validius*, Nordstedt.
Fig. 25. *C. regnesi*, Reinsch, var. *ornatum*, n. var. .. .. × 1,000

PLATE III.

Fig. 26. *Cosmarium holmiense*, Lundell, *forma minor*.
Fig. 27. *C. naegelianum*, Brébisson, var. *latum*, n. var.
Fig. 28. *C. turnerianum*, n. sp.
Fig. 29. *C. sub-cyclicum*, n. sp.
Fig. 30. *C. heliosporum*, n. sp.
Fig. 31. *C. amplum*, Nordstedt.
Fig. 32. *C. quadrifarium*, Lundell, var. *gemmulatum*, n. var.

PLATE IV.

Fig. 33. *Xanthidium intermedium*, n. sp.
Fig. 34. *Arthrodesmus convergens*, Ehrenberg, var. *divaricatus*, n. var.
Fig. 35. *Staurastrum dilatatum*, Ehrenberg, *forma*.
Fig. 36. *S. bieneanum*, Rabenhorst, *forma minor*.
Fig. 37. *S. sub-amœnum*, n. sp.
Fig. 38. *S. alternans*, Brébisson, var. *sub-alternans*, n. var.
Fig. 39. *S. striolatum*, Naegeli, var. *acutius*, n. var.
Fig. 40. *S. ventricosum*, n. sp.
Fig. 41. *S. splendidum*, n. sp.
Fig. 42. *S. pileatum*, Delponte, var. *inflatum*, n. var.

PLATE V.

Fig. 43. *Staurastrum pseudoligacanthum*, n. sp.
Fig. 44. *S. spinuliferum*, n. sp.
Fig. 45. *S. pseudassurgens*, n. sp.
Fig. 46. *S. inconspicuum*, Nordstedt, *forma gracilior*.
Fig. 47. *S. furcatum*, Ehrenberg, *forma?*
Fig. 48. *S. brachiatum*, Ralfs, var. *gracilius*, n. var.
Fig. 49. *Tetmemorus granulatus*, Brébisson, *forma minor*.
Fig. 50. *Penium cucurbitinum*, Bisset, var. *sub-polymorphum*, Nordstedt.
Fig. 51. *P. polymorphum*, Perty, *forma*.

Fig. 51A. *P. navicula*, Brébisson.
Fig. 52. *P. incrassatum*, n. sp. (?).
Fig. 53. *Docidium nodosum*, Bailey.

PLATE VI.

Fig. 54. *Docidium ovatum*, Nordstedt, var. *tumidum*, n. var.
Fig. 55. *Closterium dianæ*, Ehrenberg, var. *arcuatum*, Brébisson: the frond × 200; end and middle × 700.
Fig. 56. *C. venus*, Kützing .. .. × 300
Fig. 57. *C. cynthia*, de Notaris, *forma*.
Fig. 58. *C. decorum*, Brébisson, *forma gracilior*.
Fig. 59. *C. prælongum*, Brébisson.
Fig. 60. *C. lineatum*, Ehrenberg, var. *sandvicense*, Nordstedt .. × 200
Fig. 61. *Closterium* (?) or *Raphidium* (?) .. .. .. × 200

ART. II.—*On the Botany of Te Moehau Mountain, Cape Colville.*

By JAMES ADAMS, B.A.

[*Read before the Auckland Institute, 22nd August, 1888.*]

CAPE COLVILLE PENINSULA terminates at its northern end in the high range called Te Moehau. This range may be said to commence on the saddle between Cabbage Bay on the west and Matamataharakeke on the east, from whence, rising gradually, it extends to the saddle between Waiaro Valley and Port Charles. Then it rises with a steep incline into the mountain Te Moehau, which has an altitude of 2,750ft.

All the approaches to this mountain are very steep, but especially at the northern end, where the spurs rise abruptly from the sea. The appearance of this end is the more forbidding from the high and rugged rocks that stand in the sea at a little distance from the shore. There is a weird look about the mountain, from whatever point it is seen, which is greatly owing to two bare peaks that tower up to form the summit. The Maoris, who are rather numerous on the coast at Otautu, Waiaro, and Port Charles, have a great dread of the upper parts of the mountain. They say that long ago their numbers were much greater than at present, and that every port from Cabbage Bay on the west to Matamataharakeke on the east was thickly peopled by the powerful and warlike tribe of Ngatirongo. In those good old times the interior was occupied, they say, by Turehu or Patupaiarehe, a race short in stature and of fair skin. The Turehu only ventured to the sea-shore at night, when large parties could be seen busily engaged in fishing. As soon as the Maoris attempted to approach, the Turehu fled to the hills, leaving the refuse of the fish and the scales. These Turehu could often be heard—voices of men, and women, and children were

audible in the dense bush on misty days and on dark nights. Their favourite fishing-place was Ongohi, near Port Jackson, and their home was near the summit of the mountain. This story of the dimly-seen Turehu is told with regard to other lofty mountains in the North Island, such as Pirongia, and may refer to the war to the knife that always existed in barbarous times between the inhabitants of the shore and those of the mountain, and that still exists in some of the islands of the Pacific. It is the inexpiable war between the conquerors and the conquered, whether we read of it in Ancient Greece or in Ancient Britain.

Hoping to gain further information on the dread the Maoris have of the interior, I obtained, through the kindness of Mr. Lee, of the survey party, one of the Maori *tapu* legends. This legend shows that the Ngapuhi occupied Barrier Island and the Ngatirongo the Moehau district, and recounts a raid made by the latter on the former; but, as it does not bear directly on the dread that the Maoris have always had of the interior, it need not be further mentioned.

The dread of the Turehu no doubt hindered the natives from ascending the mountain; but it is surprising that the natural indomitable curiosity of some colonists did not urge them to the summit. Several, as I have heard, made the attempt, but for one reason or another gave it up; and a successful ascent was not made until January last, when my son and I succeeded in accomplishing it.

I must, however, confess my belief that, if a suspicion existed among botanists that the top of Te Moehau was a veritable garden of rare plants that could not be found nearer than the Ruahine Range, in Hawke's Bay District, this would have been sufficient inducement to have had the mountain-top explored long ago. There was no ground for such a suspicion. The botany of the other high peaks on the main range of Cape Colville Peninsula is very well known, and, although there may be a slight variation in some of the plants, yet the vegetation on all the peaks is strikingly similar. A catalogue of the plants on Kaitarakihi, east of Puriri, and of Maruaepuke, east of Tapu, differs very slightly.

One or two of the Ruahine plants appear on Castle Rock, east of Coromandel; but this would not warrant a guess at the riches of Te Moehau in this respect.

For some years I had been hoping to explore the Moehau Range in order to complete what had been done on the rest of the peninsula, and an opportunity offered in January last, when my son was carrying on a survey in the Moehau district. The survey camp was at Torehina, in the neighbourhood of Cabbage Bay, and, as I spent a few days there before I made the ascent of the main range, I was enabled to devote some time

to the botany of the lowlands. No situation could appear more suitable for studying the botany of the district, as there is along the coast at Torehina a great variety of land-formation. A broad band of blue and green slate is succeeded by a projecting headland of breccia, and this again by beds of marly limestone that show in the streams blocks of immense fossil oysters (*Ostræa wullerstorfii*). This formation is again succeeded by excellent crystalline limestone, which in some places forms cubical masses built up, as it were, of immense slabs. These slabs are frequently almost entirely composed of echinodermatous fossils.

There is a large area of open fern-land, extending from Torehina to Paparoa, a distance of four miles southward, which is surrounded inland by well-wooded steep ridges.

This open country was formerly occupied by Maoris, but at present there remain only two Maori enclosures, that had at the time of my visit each a few square yards of kumara and hue (*Cucurbita*).

The streams on the sea side either flow over the slate in a succession of waterfalls, or cut through the marly beds, or force their way through rounded boulders of trachyte. The outlet of each stream when it reaches the shore is banked up by sand.

The beach is in many places adorned by pohutukawa (*Metrosideros tomentosa*), that grows in great profusion, and frequently forms large clumps that are very conspicuous when the tree is in flower. It is not only on the beach that this tree is found, but it extends inland, and grows at a considerable height on the ridges.

The trees growing with the pohutukawa are karo, horoeka (*Pittosporum crassifolium, P. umbellatum*), ngaio (*Myoporum lætum*), karaka (*Corynocarpus lævigata*), kowhai (*Sophora tetraptera*), and oho (*Panax lessoni*).

In sandy places, near the pohutukawa, *Isolepis nodosa*, intertwined with *Calystegia soldanella*, quite covered the ground; and in rocky places *Sicyos angulatus* and *Bidens pilosa* are sometimes very abundant.

The cliffs that rise above the breccia on the beach are covered with *Mesembryanthemum*, *Linum*, *Sonchus*, *Astelia banksii*, patches of *Paspalum scrobiculatum*, *Bromus arenarius*, *Oxalis corniculata*, and *Arthropodium cirrhatum*. *Cassinia leptophylla* and *Veronica pubescens* are not uncommon, and on the islet-rocks at some distance from the shore *Coprosma baueriana* is very conspicuous.

The islets near the shore are worthy of some remarks, as they extend, at various distances from the mainland, along the coast from Coromandel Harbour to Cabbage Bay. They can be observed in every stage of formation. In the first

stage the end of a projecting spur has a passage between it and the mainland; then there are islands that are left high and dry at low water; and lastly there are in some places, as at Paparoa, a long line of small islands parallel to the shore and distant from it perhaps two miles. This all tends to show the inroads that the sea has been making for ages on the peninsula. The pohutukawa is sure to be found on any of these islands, no matter how small it may be. The most interesting plants that I found on the beach were *Fuchsia procumbens*, *Veronica pubescens*, *Pimelea urvilleana*, and *Pisonia brunoniana*. These plants, though now rare, were gathered by the first botanists that landed on the shores of New Zealand, as their collections were, for the sake of safety, confined to the sea-shore, and they appear to have done their work very thoroughly. The adjectival form of the name of Banks, Solander, Forster, D'Urville, Lesson, and Cunningham is the attribute of many a plant that still flourishes on the beach in unfrequented places. The fact that *Salsola australis*, common at Torehina, is omitted from their collections appears to be a good reason for regarding it as a naturalised plant.

The open land is covered with the usual ericetal plants, *Pomaderris*, *Leptospermum*, *Leucopogon*, and *Pteris*; and in sheltered places kowhai (*Sophora tetraptera*), akeake (*Dodonæa viscosa*), tupaki (*Coriaria ruscifolia*), karioi (*Rhipogonum scandens*), wharangi (*Melicope ternata*), and titoki (*Alectryon excelsum*), form pretty groves. There is an abundant but apparently second growth of trees over part of the limestone formation, where *Clematis*, *Parsonsia*, *Passiflora*, and *Lygodium* are hanging from and interlacing mahoe (*Melicytus ramiflorus*), titoki (*Alectryon excelsum*), makomako (*Aristotelia racemosa*), and miro (*Podocarpus ferruginea*). The slabs of limestone are often covered with *Peperomia*.

This open land, as I have said before, is surrounded by steep ridges that rise abruptly from streams that flow at their base. Both sides and summit are clothed with forest that on the steep inclines appears little disturbed by man or beast. And the effect is often very pleasing, of a widespread mantle of green of ever-varying shade, extending from the stream at the base to the blue sky above. Along the streams at the base the plants most frequently seen were mahoe (*Melicytus ramiflorus*), wharangi (*Melicope ternata*), *Fuchsia excorticata*, *Carpodetus serratus*, hangehange (*Geniostoma ligustrifolia*), nikau (*Areca sapida*), whau (*Entelea arborescens*), and korau (*Cyathea dealbata*). On the steep incline the following formed the greatest part of the vegetation: *Metrosideros robusta*, *M. hypericifolia*, *M. scandens*, *Myrtus bullata*, *Panax edgerleyi*, *P. arboreum*, *Coprosma robusta*, *Brachyglottis repanda*, *Myrsine*

salicina, *M. urvillei*, *Olea cunninghami*, *Veronica salicifolia*, *V. macrocarpa*, *Vitex littoralis*, *Hedycarya dentata*, *Laurelia novæ-zelandiæ*, *Bulschmeidia tawa*, *Litsæa calicaris*, *Pimelea virgata*, *P. prostrata*, *Dacrydium cupressinum*, *Agathis australis*.

The size and beauty of the puriri (*Vitex littoralis*), kohekohe (*Dysoxylum spectabile*), nikau (*Areca sapida*), and ponga (*Cyathea medullaris*) are worthy of notice. I found the tawa was by no means plentiful, and I looked in vain for tawhero (*Weinmannia*).

On the highest peak, Te Matau a Maui, 1,018ft., there was a fine specimen of *Veronica pubescens* fully 7ft. high and symmetrically grown. Other plants, as *Panax arboreum*, *Rhabdothamnus solandri*, *Astelia trinervia*, were also very large. The grasses *Microlæna avenacea*, *M. polynoda*, *Poa anceps*, and the sedges *Uncinia australis* and *Carex dissita* formed quite a sward. On the top there is a castellated mass of porphyry trachyte, and over it *Adiantum hispidulum* grows in the same profusion as the *Peperomia* over the limestone slabs.

From the top there is a fine view of the inlets and islets along the west coast, but on the east the view is into Cabbage Bay. The streams from the hill-side into this bay end abruptly in a large swamp called the Pakorero. As this swamp appeared to offer a favourable locality for plants other than those I had seen, I spent a day in exploring it. The plants in it are few in the number of species and very common. Raupo (*Typha angustifolia*) forms a large part of it; then *Cladium glomeratum*, *Juncus planifolius*, *Cyperus ustulatus*, *Sparganium simplex*, *Hydrocotyle asiatica*, *Haloragis micrantha*, *Drosera binata*, *Eleocharis acuta*, and *Lobelia anceps* are the ordinary plants. There is an abundant growth of *Isachne australis* and *Deyeuxia billardieri*. In dry places in the swamp I observed *Pittosporum tenuifolium*, *Aristotelia racemosa*, *Coriaria ruscifolia*, *Rubus australis*, *Myrtus bullata*, and *Coprosma spathulata*.

Native grasses are plentiful about Torehina, and this will account for the number of wild cattle of which the ownership is very doubtful. The grasses I have catalogued are *Microlæna avenacea*, *M. polynoda*, *Paspalum scrobiculatum*, *P. distichum*, *Isachne australis*, *Zoysia pungens*, *Dichelachne crinita*, *D. sciurea*, *Deyeuxia forsteri*, *D. billardieri*, *Arundo conspicua*, *Danthonia semiannularis*, *Trisetum antarcticum*, *Poa anceps*, *Bromus arenarius*, *Triticum multiflorum*.

During the time I was making a catalogue of the lower ground I often looked with anxiety to the distant peak of Moehau, that sometimes appeared in bright sunshine, and at other times under a dense cloud. The distance I had calcu-

lated to be about nine miles in a straight line; but, as no European had been to the top, and as the Maoris believe that the mountain is the abode of Turehu, there was only the imagination to be relied upon for the difficulties to be encountered. On Friday, 13th January, my son was able to arrange that the survey work could go on for a couple of days in his absence, and so, by making an early start, we got to the south side of Cabbage Bay at 6 a.m. This bay we could have walked across if the tide had been out, but unluckily it was high water. A boat was at hand, and a good-hearted settler might have put us over, but such good luck is not experienced by amateur botanists. There was nothing for it but to walk round the bay, where roads and tracks are in the most primitive condition. Near the ford where the bay is crossed there is the house of a settler, who is also postmaster. This house is cut off from the other part of the settlement by an arm of the bay. Over this inlet a crossing is made by a succession of nine-inch planks, that are supported by a number of embankments. Where the water is not very deep the traveller wades through it. Now, as this is the only means of communication between the settlement and the post-office, it appears very judicious on the settlers' part to prohibit in the district the use of intoxicating drinks, as it saves the expense of a resident coroner. After crossing the planks, the next obstacle in going round the bay was to wade a tidal stream, and then, after a little dry walking, to cross a swamp. The next stream in our course was so deep that some Maoris put a boat across to ferry us over. There is a good track then to Waiaro, which appears to be an important native settlement, as the whares form a good-sized village near the sea, and there is a wide stretch of level ground. Along the Waiaro stream and in the lower part of the valley the soil is very light over the clay-slate, so that the cultivations are on the slope of the hills.

The district must have supplied a large quantity of kauri, as there is about a mile of railway and a steam locomotive. There are still some logs to be removed, but the supply from the hills seems to be exhausted. Along the valley there is no devastation of native trees. The mahoe, manuka, ngaio, puriri, kohekohe, akeake, kowhai, karaka, rewarewa, and raukawa grow well, and look all the better on account of the abundance of climbing-plants and epiphytes that overspread them. The kohia (*Passiflora tetrandra*) is very abundant, and hangs down in graceful festoons over the stream, while karioi, mangemange, clematis, and tataramoa twine and intertwine as they unite tree to tree. The karo (*Pittosporum cornifolium*), broadleaf (*Griselinia lucida*), and kahakaha (*Astelia solandri*) grow luxuriantly in the upper parts of the branches.

After ascending the valley the top of Moehau and the undulating ridges that lead to it came into view. All the high ground is densely covered with forest, but on the lower part of the range, where the kauri formerly grew, a fire had been raging for some days before our arrival. The steep spurs were black and smoking, and some large trees were still burning; but the rain that had fallen the previous night and also during the morning had cooled the ground. My son, who was leader of the expedition and carrier of the swag, took a leading spur on the right bank of what had been a driving-creek for kauri logs, and after a steep climb of about 1,000ft. we reached the bush that had not been touched by the fire. My first impression of the ridge that we were now to follow was that it was impassable—kiekie, mangemange, and karioi twined and intertwined in the wildest confusion. Any opening between these intertwining creepers was occupied by *Gahnia lacera* and *Astelia grandis*. My guide, however, took no notice of these obstacles. Where there was no way over, a passage could be made under, and, by crawling sometimes very close to the ground, and sometimes by walking on partly-fallen trees some distance above the ground, progress was made. I was more than once advised to crawl on my hands and toes, and not on my hands and knees; but, although I have no doubt the former is the correct way, yet I feel sure that it is acquired by long practice only, so that I had to do as well as I could on hands and knees. We advanced for a couple of hours in this way, when we reached the main range. The way was now more open, and there were signs of a survey party, at some distant time, having been on the ridge, and shortly afterwards we reached the trig. station, that has an elevation of 2,054ft. The plants I observed here were those that occurred with more or less frequency afterwards on the ridge as we advanced towards the summit. They are *Drimys axillaris*, *Melicytus ramiflorus*, *M. lanceolatus*, *Eleocarpus hookerianus*, *Quintinia serrata*, *Ixerba brexioides*, *Weinmannia sylvicola*, *Myrtus bullata*, *Fuchsia excorticata*, *Alseuosmia macrophylla*, *Coprosma robusta*, *C. fœtidissima*, *Senecio gladifolius*, *S. myrianthos*, *Dracophyllum latifolium*, *Rhipogonum scandens*, *Astelia grandis*, *A. trinervia*, *Pteris incisa*, and *Polypodium rugulosum*. The two last-named had no doubt arrived since the trees at the trig. station had been levelled. The largest trees on the range are tawhero (*Weinmannia sylvicola*) and pukatea (*Laurelia novæ-zelandiæ*.)

The ridge leading to the peaks, though it appears from a distance to undulate gracefully, was found to be very irregular. A steep ascent was followed by a steep descent, and then succeeded a broad saddle on which supple-jack, kiekie, and mangemange grow in surprising luxuriance. On these saddles

it was often doubtful what was the real summit of the ridge until another ascent and a favourable opening revealed the highest peak looming in the distance.

When sunset was near we followed down a dry water-course for a couple of hundred yards, and found a water-hole. We camped near it for the two nights we were on the mountain, and I was surprised to notice, as we left the place, that the mere requirements for beds and fuel had so exhausted the number of trees and ferns that the camping-place looked like a clearing. The *Gahnia*, *Freycinetia*, and *Rhipogonum* that grow so densely on the ridge do not flourish on the clay-slate that is in loose shingle on the sides. The scanty bush covers what had for ages been extensive shingle-slopes.

The ordinary plants are *Melicytus ramiflorus*, *Schefflera digitata*, *Brachyglottis repanda*, *Areca sapida*, *Hemitelia smithii*, and *Aspidium aculeatum*. *Polypodium pennigerum* grows very large and stalked. I saw *Lomaria nigra* in two places, but I looked in vain for *Loxsoma cunninghami* and *Lomaria elongata*.

The next morning we followed up the dry bed of another watercourse, that brought us nearer to the peak, and on reaching the summit our work began. In addition to the undergrowth that was experienced before, *Alseuosmia* and *Coprosma fœtidissima* formed dense thickets on the ridge, and of course there was no such thing as walking. We had literally to thread our way. If the explorer be regarded as a long needle, his progress past the vegetation will closely resemble darning. The dense tangle appeared to get worse and worse, when we suddenly struggled on to a mass of *Metrosideros albiflora*, and there close at hand was open ground and the rounded peak covered with stunted vegetation. Several large flat rocks hoary with *Racomitrium* moss were close to the dense bush, and on these were growing in great profusion *Celmisia incana* in full flower. Every step in the open ground not only showed that the vegetation was a contrast to that on the ridge, but also that it was unlike that of any other high peak on the main range throughout the peninsula. I could scarcely believe my eyes as each fresh plant that I saw seemed to show that I was on the top of one of the mountains in Nelson Province. There are patches of *Oreobolus* and *Carpha alpina*, studded with the mountain form of *Ourisia macrophylla*. Tufts of *Pentachondra* and *Cyathodes empetrifolia* are conspicuous on the little mounds of peat, and then the largest part of the surface of the ground is carpeted with lycopods, the alpine forms of *Gleichenia dicarpa* and of *Danthonia semiannularis*.

The Moehau peak is a rounded mass of augitic andesite intruded between the slate formation of which the mountain

is composed. It runs about 200ft. above the ridge in a gradual slope, and there is no part of the sides or summit bare. The open land around it may be about a hundred acres, and it is distant from the lower peak about a mile.

On the flat and rounded top the tallest plants are stunted neinei (*Dracophyllum latifolium*) and clumps of *Phormium colensoi;* while *Gaultheria antipoda, Corokia buddleoides*, and *Coprosma colensoi* are very stunted, and grow little higher than *Gleichenia dicarpa, Lycopodium varium*, and *L. scariosum*. In a sheltered part near the summit *Dacrydium bidwillii, Phyllocladus glauca, P. alpina, P. trichomanoides, and Podocarpus nivalis* grow well.

The following is the list of plants that I observed on the peak: *Fuchsia excorticata, Panax sinclairi, P. colensoi, P. edgerleyi, Corokia buddleoides, Coprosma lucida, C. colensoi, Celmisia incana, Gaultheria antipoda, Cyathodes empetrifolia, Pentachondra pumila, Dracophyllum latifolium, Myrsine salicina, Ourisia macrophylla, Phyllocladus glauca, P. alpina, P. trichomanoides, Dacrydium bidwillii, Podocarpus nivalis, Dendrobium cunninghami, Thelymitra longifolia, Astelia linearis, Arthropodium cirrhatum, Danthonia semiannularis* var. *alpina, Gleichenia dicarpa* var. *alpina, Hymenophyllum multifidum, Trichomanes reniforme, T. venosum, T. rigidum, Lomaria lanceolata, Schizæa fistulosa, Lycopodium varium, L. volubile, L. densum, L. billardieri, L. cernuum, L. scariosum.*

Some of these plants are not found nearer than the top of Hikurangi, in the Ruahine Range—viz., *Celmisia incana, Pentachondra pumila, Ourisia macrophylla, Phyllocladus alpina, Dacrydium bidwillii, Podocarpus nivalis, Danthonia semiannularis* var. *alpina, Oreobolus australis, Carpha alpina, Gleichenia dicarpa* var. *alpina.*

At the base of the peak, on the borders of the thick forest, *Panax sinclairi, Corokia buddleoides*, and *Metrosideros albiflora* are very abundant, but I did not see them anywhere else on the range. The *Metrosideros albiflora* was the only rata I saw on the mountain. On the day we reached the top there was no wind, but, as all the shrubs had the ground hollowed out at the base of the stem, it is evident that a calm is a very unusual thing at the summit. The appearance of Ruahine plants on the summit is the more remarkable, as Maruaepuke, Kaitarakihi, and Te Aroha are respectively two or three hundred feet higher; and it appears to me to prove that Moehau is the oldest land-formation on the Cape Colville peninsula.

From the top of the elevated dome, with its dwarfed vegetation, the view over the forest that covers the mountain is quite unimpeded. The sharp ridges and deep valleys are clearly visible.

There is no open line or even break in the vegetation, but

the eye wanders over an ever-varying prospect of sombre green. From the outline of the ridge by which we ascended other ridges constantly diverged to the right and to the left, showing plainly that the return to our camp was no simple matter. Looking to the south, the whole main range was visible to Maruaepuke, which appeared just on the horizon. The deep gulf forming Coromandel Harbour, with the islands and islets near it, were distinctly visible. Then the eye could follow the irregularities of the coast to the survey camp at Torehina, and could look into Cabbage Bay, the Otautu settlement, and the Waiaro Valley, through which we had ascended. On the east coast a large portion of Port Charles was visible, while farther south Mercury Island and the islets near it were quite distinct. To the north, Barrier Island was clearly defined, and away to the west every island and islet in Auckland Harbour was distinctly outlined.

We did not reach our camp that night, but, sorely against our will, were forced to explore the eastern ridges and deep mountain-gullies. We lost and found the main ridge over and over again; but soon it became too dark to move, and, after a frugal supper of nikau and water, we sat uneasily on the loose shingle by a fire and waited for daylight. Not a sound was heard in that lonely forest, except at long intervals the sharp noise produced by the *weta* and the continuous muffled sound in the distance of falling water.

There is nothing upon the mountain to support life—neither bird nor beast—so that there was no inducement for the ancient Maori to ascend it; and, as no kauri grows there above the level of 1,000ft., there is no attraction for the gum-digger: so that, after a few expeditions have been made to fully explore the summit for plants, Te Moehau will probably be left undisturbed except by the wind.

ART. III.—*A Description of a Species of* Orobanche *(supposed to be new) parasitical on a Plant of* Hydrocotyle.

By WILLIAM COLENSO, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 12th November, 1888.*]

Orobanche hydrocotylei, Col.

PLANT erect, simple, 12in.–18in. high, cylindrical, rather stout, as thick at base as a large-size common lead-pencil, darkish purple-red; whole plant thickly glandular-pubescent; hairs short, patent, whitish, their globular tips yellow. Bracts scattered, few at base, very distant below on stem, ¾in.–1in.

apart, and (with flowers) mostly running in three lines; ovate-acuminate, dark-purple, many veined; tips recurved.

Flowers 20–40, loosely spiked on upper two-thirds of stem, distant throughout ½in.–¾in. apart, presenting a sub-decussate appearance, sessile; floral bract as long as corolla.

Calyx beneath only (corolla naked at top and sides), purple, ovate-acuminate, 2-leaved, each bilobed nearly to base; lobes long acuminate, unequal, the outer lobe twice the length of the inner one and half as long as corolla, sub-erect, divergent, their margins slightly and finely sub-denticulate and much ciliate.

Corolla sub-ascending, patent, arched, 7–8 lines long, cylindrical, mouth broadly dilated, margins recurved; the upper half purple above; base and sides white; veins dark-purple; lips whitish dashed with purple, their margins irregularly denticulate or laciniate-toothed, wavy; glabrous within, shining; the upper lip projecting beyond the lower one, deeply emarginate or sub-bilobed, lobes rounded, sometimes slightly decurved; the lower lip larger, much recurved, sub-3-lobed, lobes nearly equal in length, the middle lobe shortest obtuse rounded, lateral lobes large spreading puckered, with inner margins incurved and much rumpled and inflated, somewhat like two sub-calli, each with a large ochraceous spot or dash.

Stamens inserted near base of corolla, stout, glabrous, flexuous, about half as long as corolla; anthers reniform-orbicular, mucronate; light umber-brown. Style thick and dilated at top, glabrous, with a few (5–6) scattered microscopic glandular hairs near top. Stigma large, recurved, bilobed; lobes globular, spreading, purple, finely papillose: finally exserted. Ovary ovoid.

Hab. Parasitical on the roots of a small spreading *Hydrocotyle* (*H. sibthorpioides*, Col.), the foster plant originally brought from forests near Dannevirke, County of Waipawa; 1887: *W. C.*

Obs. This plant is in many respects a remarkable and interesting one; especially if (as I at present believe) it should prove to be a new species, as such has not yet been detected in this country, nor in the Southern Hemisphere. I will therefore briefly give its history:—

In 1887 I planted in a large-size flower-pot some *Pterostylis*, and *Thelymitra* tubers (these subsequently flowered), and with them a small neat *Hydrocotyle*, which I had also brought from the woods in the interior, as I wished to see its ripe fruit. The *Hydrocotyle* plant grew amazingly, throwing out scores of long filiform branches, 2ft.–3ft. long, and covered with flowers and fruit; and has proved to be—what I had supposed—a new species.* Suddenly (early in September,

* *H. sibthorpioides*, Col. (*Vide* description in Art. V., p. 33.)

1888) there appeared a large, closely-bracteated, purple head, rising from among the thickly-overgrown *Hydrocotyle*, and in a few days two more, strongly resembling the purple heads of asparagus in colour and form, only these were densely pilose. These heads grew very fast, and were soon found to be a species of *Orobanche*. They were all very much alike, merely differing in height, and, consequently, in the number of their flowers: one attained the height of 18in., with forty flowers; another 15in., with thirty-three flowers; and the third, 12in., with twenty flowers. And subsequently (about five to six weeks later) a fourth and similar one made its appearance. This plant differs considerably from all our British species (of which I have botanical drawings), and from the Australian "introduced" one described by Bentham (which is also European), and from several others whose descriptions I possess; still, there are more described, of which, however, I am ignorant, therefore this plant may yet come under one of these. I have no recollection of ever having seen the *whole* plant before; but, at the same time, I have a strong suspicion that I have noticed something arising from the thick beds of our largely-creeping pilose *Hydrocotyle* very much like what the heads of this plant were in their early incipient state.* It is, however, new to science to find this parasite growing on *Hydrocotyle*; also, under cultivation; and then to have three (now four) together is equally rare. The foster plant, though exceedingly slender and delicate, is apparently as healthy and flourishing as ever.

ART. IV.—*A Description of some newly-discovered Cryptogamic Plants; being a further Contribution towards the making known the Botany of New Zealand.*

By W. COLENSO, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 12th November, 1888.*]

ORDER IV.—MUSCI.

Genus 67.† **Hypopterygium**, Bridel.

a. **Leaves not mixed with bristles.**

1. *H. vulcanicum*, sp. nov.

Root thickish, sub-rigid, 3-pinnately branched, much im-

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* See, for instance, a notice of an abnormal vegetable form observed (not wholly dissimilar) under *H. concinna* ("Trans. N.Z. Inst.," vol. xvii., p. 239). This *Orobanche* in its earliest stage might easily have been confounded with such in the gloom of the forests.

† The numbers here attached to orders and to genera are those of the "Handbook of the New Zealand Flora."

plexed; branches alternate, distant, straight; tips flexuous, acute. Stem 1in. high, pale, succulent, with red hairs in scattered dense bunches. Frond sub-flabellate-ovate, ½in. long, pinnately branched; branches few (4–9), simple, close not imbricate, pale-green. Leaves—lower on main stem, scale-like, distant, deltoid, entire, apiculate; nerve 0, instead of a nerve longitudinal cells extending throughout to apex, and cells of lamina oblong-hexagonal: upper on main stem, close not imbricate, oblong-ovate, dimidiate, margined, slightly serrate on upper apical portion, more so on the anterior margin, tip much apiculate, biserrate: on branches, narrower acuminate: dorsal leaves on main stem, sub-orbicular, margined, much apiculate; nerve stout, extending two-thirds of leaf; cells clear, oblong, rather small, with minute cellules, smallest at margins, large at centre and base: leaves on branches narrower, broadly oval, entire, margin slightly uneven; tip very apiculate, the mucro long and flexuous.

Hab. Among stones and pumice, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Owen.*

Obs. The roots of this little plant are curious, widely differing from those of other species of this genus, no doubt owing to its high, exposed, and arid habitat. I regret not receiving any fruiting specimens.

2. *H. marginatum*, sp. nov.

Stem 1½in. long, sub-rigid, dry, flexuous, flattened, with distant small scarious scales, reddish with dark-red rootlets scattered in little bunches. Frond small, oblate-orbicular, ½in. wide, with 16 short spreading branches, pale-green. Leaves close, imbricate, ovate, acute, apiculate, margined, a few minute teeth near tip; nerve stout, extending nearly to apex; cells small, regular, oval, with double walls and minute cellules; dorsal leaves on main stem deltoid-rotund, margined, entire, very apiculate; nerve broad, strong, percurrent; cells small, oblong and rhomboidal, with minute cellules, very long at centre and base, smallest at margins; leaves on branches orbicular, strongly margined, minutely uneven, serrulate at tip, cuspidate, stout; nerve excurrent, stout, prominent.

Hab. With preceding, sides of Mount Tongariro; 1887: *Mr. H. Hill.*

Obs. A single specimen picked out from among a lot of scrap and damaged mosses.

3. *H. flaccidum*, sp. nov.

Stem slender, ¾in. high; branches simple, ¾in. long, loosely spreading, soft, flaccid. Leaves—on stem, ovate, acute, serrate, cuspidate; on branches, ovate, acute, serrate: dorsal,

ovate, very acuminate, serrate: perichætial, long, subulate, flexuous. Cells linear, long.

Hab. Dry sides of watercourses among small *Hepaticæ*, woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. Only one specimen of this very distinct species detected among my collected specimens.

Genus 71. **Hookeria,** Smith.

§ 2. MNIADELPHUS, C. Muell.

1. *H. semiserrulata*, sp. nov.

Plant terrestrial, tufted; stems brownish, 1½in.–2½in. high, 4 lines broad at top, tips curved; basal leaves small, distant, with a number of brown rootlets implexed among them. Leaves on main stem sexfariously disposed, but quadrifarious on the lower part of branches, imbricate, light-green, transparent, wavy, recurved, broadly margined, the upper half and apex finely serrate, the lower slightly irregular but scarcely denticulate: lateral leaves oblong, spreading, 2 lines long, apiculate, base dimidiate: dorsal and ventral, orbicular, apiculate; binerved, nerves united and very stout at base, unequal, divergent, the longest extending one-third to two-fifths of leaf; cells hexagonal, smaller around margins, larger oblong and rhomboidal at base. Perichætial leaves oblong-obovate, suddenly very acuminate, the narrow tip two-fifths the length of leaf, flexuous, tip acute, slightly margined and serrulate at apex; nerve 0; cells sub-linear-lanceolate, their ends thickened. Fruit-stalk ½in. long, pale-green, scabrid. Calyptra (young) narrow or straight, base fimbriate; tip obtuse, fimbriate with long wavy irregular whitish fimbriæ.

Hab. Low wet shaded woods, south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. This plant dries both crisp and green.

§ 3. PTERYGOPHYLLUM, Bridel.

2. *H. sexfaria*, sp. nov.

Plant large, terrestrial, gregarious. Stems stout, flattish, sub-erect, 3in.–3½in. high, ½in. wide at top; branches few; leafy from base. Leaves sexfariously disposed, not margined, largely serrate, tips obtuse; pale-green: lateral leaves oblong, dimidiate, 3 lines long, spreading, young tips bearing a reddish hue; dorsal and ventral, orbicular-ovate; nerve stout, extending three-fifths of leaf, bifid about the middle of leaf, colour same as leaf, but brownish-red at base. Cells large, orbicular, with clear minute triangular intermediate spaces. Perichætial leaves small, sub-ovate-acuminate, entire; tips truncate, serrate; cells narrow oblong-lanceolate; nerve 0. Fruit-stalk (young) 5–7 lines long, stout, flexuous, red, glossy, five on a

branch and near each other. Calyptra long, narrow, smooth, the base slightly laciniate.

Hab. Boggy spots, low woods, south of Dannevirke, County of Waipawa; 1888: *W. C.*

3. *H. atrovirens*, sp. nov.

Plant terrestrial, loosely tufted, sub-erect, 1½in. high. Stem simple (rarely branched), dark-coloured (young stems reddish-brown, glossy), stout, leafy, with many dark-brown rootlets at base. Leaves quadrifariously disposed, free, loosely imbricated at top, dark olive-green (young leaves green); margins entire, but under a powerful lens slightly and irregularly denticulate near tip, though not serrated; cells large, hexagonal-orbicular, but hexagonal-oblong at base, their centres blotched with irregular dark dots, very small at margins: lateral leaves spreading, 2 lines long, elliptic or elliptic-ovate, tip obtuse; nerve very stout, colour of leaf, extending two-thirds length of leaf, and slightly bifid near top: dorsal and ventral sub-orbicular, a little shorter than lateral. Perichætial small, numerous, orbicular, apiculate, apex blunt and excised on each side, serrulate; cells smaller; nerve 0. Fruit-stalk very stout, ½in.–¾in. long, black, shining, curved, 4–6 on a branch, thick and bulbous at base. Capsule (old) small, 1 line long, oval, slightly tubercled at base, dark-brown, nodding. Calyptra (young) linear, sub-acute, 1½ lines long, black, smooth, grey and slightly jagged at base. Antheridia, several at base of fruit-stalk, linear, swollen and brown at middle.

Hab. On the ground in a boggy spot in a low wood, south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. This plant shrivels much and becomes black in drying. Its nearest affinity seems to be with *H. quadrifaria*, Sm., and *H. robusta*, Hook. f.

4. *H. flava*, sp. nov.

Plant small, ¼in.–½in. long, leafy to base, stems branched above, main stem and branches dark-red. Leaves yellowish-green, sub-quadrifariously disposed, thickly set, imbricate, ½-⅓line long, obovate-spathulate, apiculate, tapering to base, margined, entire, slightly uneven, very crisp when dry; nerve strong, single, flexuous, extending through four-fifths of leaf. Perichætial few, erect, sub-linear-oblong, apiculate. Cells compact, orbicular, very minute at tips, larger at centre and increasing in size to base, where they are very clear parallelogrammatic and oblong-hexagonal. Fruit-stalk (immature) short. Calyptra smooth, beak very long.

Hab. Growing among and over *Zoopsis muscosa* (*infra*), woods, Dannevirke, County of Waipawa; 1888: *W. C.*

ORDER V.—HEPATICÆ.

Genus 2. **Jungermannia**, Linn.

§ 1. Stipules 0: leaves entire.

1. *J. consimilis*, sp. nov.

Plant small, procumbent, tips ascending, simple and dichotomously forked, 1in.–1¼in. long, scarcely 1 line wide, leafy throughout, the under side of stem densely clothed with fine rootlets. Leaves pale-green, close, imbricate, erect and conniving, very regular, triangular-ovate, much apiculate, narrowly margined; margins entire but uneven, slightly decurrent. Stipules 0. Cells numerous, small, orbicular, distinct, ranged in longitudinal lines, larger in centre and at base.

Hab. Growing half concealed in tufts of moss (*Leptostomum inclinans*, Br.) on branches of living trees, low woods, south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species closely allied to *J. monodon*, Hook. f. and Tayl., but differing in size, colour, leaves broader, more largely and sharply apiculate, with their margins uneven, and with smaller and much more numerous cells.

2. *J. frullanioides*, sp. nov.

Plant pleasing green, prostrate, creeping, with numerous short dark rootlets in tufts on the main stem, 2in.–4in. long, 3-pinnately branched; branches alternate, numerous, close, spreading, slender, $\frac{1}{30}$in. wide, very leafy. Leaves sub-opposite, close, imbricate, spreading, flat (concave and recurved when dry), broadly elliptic or sub-rotund, dimidiate, the upper portion finely serrulate, sub-apiculate, tapering to base and rather narrow there with a nerve-like thickening, obliquely set; the anterior basal portion overlapping stem; the posterior basal margin excised, slightly decurrent. Stipules 0. Cells very minute, sub-orbicular, regular, compact, very obscure.

Hab. On branches of living trees, forming small thick patches, woods near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. This is rather a peculiar looking species; it grows closely intermixed and thickly overrunning itself, having much of the habit and general appearance (at first sight) of some of our small *Frullaniæ*. Not having met with it in fruit, I place it under this genus with some doubt.

Genus 3. **Plagiochila**, Nees and Montagne.

§ 2. Stems sparingly branched.

1. *P. pallescens*, sp. nov.

Plant pale, slender, weak, drooping, 2½in.–3in. long, $\frac{1}{10}$in. wide, simple and 2–3 branched, leafy throughout;

branches long, their tips much drawn out, flagellate, with their leaves very minute and distant. Leaves alternate, sub-obovate-elliptic, dimidiate, close not imbricate, lacinio-denticulate on two margins, the lower side entire and nearly straight and very slightly decurrent; teeth few (5–9), very irregular in length, two (sometimes three) outermost at tip very long and straight, their sinuses large and broad. Cells minute, orbicular, sub-opaque.

Hab. Forests near Lake Waikare, County of Whakatane; 1888: *Mr. A. Hamilton.*

Obs. A delicate species, with the habit of *P. laxa*, Lehm. and Lind.

2. *P. parkinsoniana*, sp. nov.

Rhizome long, wiry. Plant very slender; stems distant on rhizome, 2in. long, 1 line wide, simple and forked; branches long, flexuous, leafy throughout. Leaves very minute at base and some distance up main stem, alternate, close not imbricate, sub-parallelogrammatic; tips truncate, 2-toothed, one at each angle, and generally one minute tooth (rarely two) just below on anterior margin, which is also slightly arched; posterior margin straight (sometimes slightly curved), entire, very slightly decurrent on dorsal side of stem. Cells minute, compact, obscure.

Hab. Dry sides of ravines, among other *Hepaticæ*, woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A long, narrow, neat species, having affinity with *P. laxa* and its allies.

3. *P. intermixta*, sp. nov.

Stems very slender, erect, simple, and once-forked near base, dark-coloured, shining, 1in.–1¼in. long, $\frac{1}{20}$in. wide. Leaves brownish, alternate, distant, patent, sub-oblate-orbicular, oblique, rather free, only a small portion attached to stem and half-clasping, concave, largely denticulate all round save the extreme base; teeth distant, irregular, straight, acute and obtuse, cellular, sinuses rounded. Cells small, sub-quadrilateral, larger and oblong-quadrilateral at base.

Hab. On rotten logs, growing closely intermixed with *Gottschea* and other *Hepaticæ*, woods, Dannevirke; 1888: *W. C.*

4. *P. orbiculata*, sp. nov.

Plant diffuse, spreading, sub-erect, slender, curved, 2in. long, 1 line wide, sub-bipinnately branched; branches few, very distant, simple, leafy throughout. Leaves alternate, close but not imbricated, orbicular, margins entire, slightly contracted at base with a nerve-like plait, patent, obliquely set on stem and decurrent across it, brownish-green. Cells

small, compact, sub-orbicular, larger at base, with thick irregular double walls and cellules in them.

Hab. On ground, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. Only a few specimens of this very distinct species seen; picked out from among *P. alpina* (*infra*).

5. *P. subconnata*, sp. nov.

Plant pale-brownish, slender, erect, 1in.–2in. high, 1½ lines wide, simple and once-forked (about middle), flexuous, leafy nearly to base, the leaves very small and distant below. Leaves opposite, orbicular, very nearly connate, $\frac{1}{16}$in. diameter, margins slightly uneven, with a few (2–5) minute denticulations at top, sometimes sinuate only, wavy, sub-amplexicaul, patent, recurved, the lowest entire. Cells sub-orbicular, of two sizes, one large distant and clear, and one minute close and numerous surrounding the larger ones. Male spikes on the middle of branches, large (for plant), 2–3 lines long, with 9–14 pairs of scales, sometimes two spikes at a short distance from each other; tips recurved, entire.

Hab. Among other *Hepaticæ* and mosses forming patches on trees, woods near Dannevirke, County of Waipawa; 1888: *W. C.*

§ 3. Stems erect from a creeping rhizome, tall, much branched, dendroid.

6. *P. longissima*, sp. nov.

Plant large, sub-erect and pendulous, sub-rigid, 4in. high; stems black, leafy to base, branched above; branches few, very long (2in.–4in.), 3 lines wide, bipinnate, sometimes sub-fascicled and opposite at middle of main stem, divergent; branchlets few, sub-opposite, spreading. Leaves brownish-green, sometimes green splashed with brown (giving out a brown colour in soaking), close, imbricate, concave, sub-trapezoid-triangular, 1½ lines long; tips truncate, 3-toothed, with usually two teeth below apex on each margin, the rest entire and straight save 5–7 long flexuous ciliate teeth on basal anterior margin, which largely overlaps on stem, meeting and standing out like a ridge, their sinuses broad and rounded; posterior margin recurved lengthways, decurrent on stem, almost meeting at lowest points. Cells orbicular, with round interstitial cellules. Perianth (old) narrow oblong-ovate, mouth sub-truncate, obtuse, with a few coarse teeth. Cells linear-oblong, close together.

Hab. On trees, thick woods, Dannevirke, County of Waipawa; 1888: *W. C.*

7. *P. subpetiolata*, sp. nov.

Rhizome long, slender, branched, creeping. Plant sub-

dendroid, erect, 1½in. high; stem dark red-brown, shining, bare below, simple, also 3-branched about the middle, and sometimes dichotomous; tops of branches curviform. Leaves alternate, rather distant on stem, patent (appressed and conniving in pairs when dry, and then slightly imbricate), orbicular, 1 line wide, denticulate, pale-green, thickish, and coloured (reddish) at junction with stem, and only slightly adhering as if sub-petiolate, not decurrent; much smaller on tips of old branches, which are drawn out and very acuminate. Cells minute, distinct, sub-orbicular, with dark walls; the centre and base of leaf black-dotted (microscopically) in transverse wavy lines. Fruiting specimens not seen.

Hab. Forests near Lake Waikare, County of Whakatane; 1887: *Mr. A. Hamilton.*

Obs. A peculiar neat-looking species, much resembling in general appearance of stems and leaves the drawing given of *Jungermannia falcata*, Hook. ("Musci Exotici," tab. 89), now *Adelanthus falcatus*, Mitten ("Handbook N.Z. Flora").

8. *P. spenceriana*, sp. nov.

Plant densely tufted; rhizome matted, creeping, wiry. Stems slender, erect, wiry, shining, sub-translucent, brown, somewhat dendroid in the large specimens, 2in.–2½in. long, 3 lines broad (including leaves), leafy to base with the leaves decreasing in size, simple and branched; branches few, lower (one or two) diverging, long, flexuous, (male plant) generally sub-fascicled above (top of main stem) into 4–5 erect equal branchlets, each bearing a terminal spike, linear-lanceolate, obtuse, flattish, canaliculate, distichous, 1¼ lines long, 10–15 jugate, their edges rounded, tips of perigonial leaves entire and slightly decurved. Leaves distant, patent, alternate, decurrent on dorsal side, biformed, olive-green: those on main stem sub-orbicular, distantly cilio-serrate at apex and upper portion of anterior margin, the posterior margin entire, recurved, slightly amplexicaul, reddish at junction with a wavy rumple or twist owing to leaf being set obliquely on stem: those on branches broadly obovate and much smaller. Cells very minute, orbicular, guttulate, crowded, obscure, with smaller cellules in their angles; slightly clearer and more regular at extreme base; those of perigonial leaves elliptic and black-beaded.

Hab. On trees, forests near Dannevirke, County of Waipawa; 1888: *Mr. H. Hill.*

Obs. I. This plant in its slender habit resembles *P. prolifera*, Mitt., although its main stems are both stouter and wider and its branches not proliferous, with leaves more closely and largely ciliate, alternate, and not coadunate; and its perigonial leaves are also entire. It is also allied to *P.*

exilis, Col., and *P. distans*, Col.,* but differs in its entire perigonial leaves, &c., and also to *P. polystachya*, Col. (*infra*). The male spike resembles that of *P. brauniana*, Nees.

II. Sometimes 3–4 male spikes are found adnate on a single main stem, beginning at a little distance from the base, and so on from each other, with a few pairs of small leaves between them. A very graceful little species.

9. *P. polystachya*, sp. nov.

Rhizome creeping, long, much-branched. Plant erect, dendroid, stiff, 3in. high; main stem woody, simple, 3½ lines wide, leafy to base, dark-brown, branched above; branches few, long, slender, spreading, alternately and equidistantly spiked, 4–6 on a branch, the leaves between them small. Leaves green, close, imbricate at bases, regular, patent, subdeltoid, apex broad, rounded and truncate, with a few (4–5) short teeth, and 2–3 longer and more acute at anterior ventral base, sometimes 1–3 distant and minute ones on ventral lateral margin, which is overlapping; dorsal margin very oblique, straight, entire, largely decurrent; both margins wavy and recurved. Cells small, densely crowded, orbicular, each surrounded by a chain of very minute and clear cellules. Male spikes sub-lanceolate, 3–2 lines long, deeply sulcate on dorsal surface, turgid on ventral, brownish-yellow, lower ones 9–10 jugate, gradually decreasing in size (6–4 jugate) to top, and so their intermediate leaves; also, sometimes five together are fascicled at apex. Perigonial leaves rather large, tips recurved, sharply acute, and 2–3-toothed.

Hab. In deep woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species having affinity with *P. spenceriana* (*supra*), but differing in its larger and more robust size, in habit, in shape of leaves, and in the apices of the perigonial leaves being toothed.

10. *P. subflabellata*, sp. nov.

Rhizome creeping, main stems erect, dendroid, wiry, stiff, woody, leafy to base, 1½in.–2in. high, 3 lines wide, including leaves, but narrower at base and on branches; bipinnately branched at top; branches few, regular, spreading nearly at right angles, graceful, almost sub-flabellate. Leaves very thin, pellucid, lively green, rather distant, not imbricate (young stem-leaves sub-imbricate), patent, 1½ lines long, sub-trapeziform (in outline), decurrent across stem; apex blunt, rounded; base sub-amplexicaul, wavy with a central hollow, convex, margins recurved; ventral and apical margins cilio-serrate,

* "Trans. N.Z. Inst.," vol. xix., pp. 282, 283.

teeth 14–16, irregular, rather distant, filled with minute cells; sinuses large, rounded, semicircular, the base much arched and overlapping stem; dorsal margins straight, entire, thickened, with rarely 1–2 very minute blunt (budding?) teeth on upper margin. Involucral leaves at tips of branches erect, broader and more largely ciliate. Cells crowded, of 2–3 kinds —(1) orbicular and clear, with minute cellules between them; and (2) beaded with black dot-like centres, these last mostly marginal.

Hab. Woods near Dannevirke, County of Waipawa; 1888: *W. C.*

11. *P. alpina*, sp. nov.

Plant sub-dendroid, 2in.–2½in. high, 2 lines wide; stems sub-succulent, 3-pinnately branched above; branches irregular, leafy, pale-green young, dark-coloured in age. Leaves sub-vertical, distant and smaller on main stem, sub-imbricate on branches, rotund, 1 line diameter, slightly dimidiate, set obliquely, contracted at base, slightly amplexicaul, much decurrent, concave and slightly plaited, toothed; teeth irregular, mostly alternately long and short, margins of both anterior and posterior bases entire. Cells compact, sub-orbicular, their walls thick and dark, with minute cellules in them.

Hab. On the ground in tufts among other small plants, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

12. *P. berggreniana*, sp. nov.

Plant largely tufted, sub-erect, densely overgrowing. Stems 1in.–3in. long, 2½ lines wide, light-brown, leafy to base, simple, forked and branched irregularly above; a sub-flagellate branch usually springs from base of perianth. Leaves light-green: those on main stem sub-opposite, regular, close not imbricate, spreading, sub-obovate-reniform, dimidiate, narrowest at base; tip obtuse and (with anterior margin) distantly toothed; posterior margin entire, straight and slightly curved, slightly decurrent: those on branches smaller and more distant, with fewer (3–4) teeth at apex. Involucral leaves similar to those on main stem, broader, erect, more toothed. Cells rather large, compact, obscure, oval and sub-orbicular, with minute interstitial ones. Perianth terminal and axillary between two divergent branches, obovate, mouth small, slightly and irregularly toothed, two of the teeth rather long and coarse. Fruit-stalk short, scarcely exserted. Capsule brown; valves oblong-lanceolate, sub-acute.

Hab. On trees, woods south of Dannevirke, County of Waipawa; 1888: *W. C.*

Genus 5. **Lophocolea**, Nees.

1. *L. submuricata*, sp. nov.

Plant minute, creeping, simple, 1in. long, $\frac{1}{20}$in. wide, pale greenish-white, having a rough sub-muricated appearance; pinnatifid, lobes cut nearly to base, close but not imbricate, adnate, sub-trapeziform, broadest at base, tip truncate and sub-trifid, spiny ciliate at apex and on anterior margin; posterior margin entire and largely oblique; cells minute, circular, obscure, with a few scattered clear ones; ciliæ close, irregular, straight and branched, the sinuses very broad and rounded at bases. Stipules minute, capillary, forked, each ray compound of two or more branches.

Hab. On the ground among other and larger *Hepaticæ*, damp low forests, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. This is a very peculiar-looking plant, differing widely from other *Hepaticæ* I have seen: its almost jagged leaves and compound or branched spiny ciliæ give it a unique appearance. From not finding it in a fruiting state it is only provisionally placed under this genus, *Lophocolea*, as it may prove to be a *Leioscyphus* or a *Chiloscyphus*.

Genus 7. **Gottschea**, Nees.

* Leaves stipulate.

1. *G. guttata*, sp. nov.

Plant small, gregarious, sub-procumbent, broadly obovate, $\frac{3}{4}$in.–1in. long, 5 lines wide at top, simple, sometimes shortly branched below, leafy from base; rootlets numerous, very stout, wiry, dark-purple. Leaves close, imbricate; ventral lobe narrow ovate, irregularly laciniate-serrate, tip sub-acute; dorsal lobe extending two-thirds of leaf, tip truncate, the anterior base largely rounded and produced beyond leaf, the margin uneven with small and distant denticulations; the posterior margin nearly straight, and not near margin of ventral lobe, with a straight plait running from the lower corner of the tip to the margin of ventral lobe. Stipules large, sub-orbicular (in outline), narrowest at base, bilobed, each lobe truncate and laciniate, usually three laciniæ on each side and three at top; laciniæ curved, stout, 6–7 cells wide at bases, their tips acute; sinus deep, sub-cuneate. Cells very large, orbicular-elliptic, double-walled and guttulate, having a very peculiar and rich appearance, as if each cell were separately embossed.

Hab. Among mosses on decaying logs, low woods, south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species near to "*G. compacta*,"* Col. ("Trans. N.Z. Inst.," vol. xix., p. 285), but differing in its smaller size, in its different habit of growth, in its lobes and stipules being less serrate and laciniate, and in the unique formation of its large cells.

2. *G. longiciliata*, sp. nov.

Plant gregarious, small, flat, spreading, broadly obovate, 1in. long, 4 lines wide at top, mostly simple, sometimes with two short opposite branches near apex. Stem stout, dark-coloured, leafy to base; rootlets numerous, wiry, dark-purple. Leaves pale-green, much and closely imbricate, translucid; ventral lobe ⅛in. long, ovate, obtuse, entire, finely serrulate; dorsal lobe short, two-fifths length of ventral, tip truncate, wide, anterior margin ciliate, not produced beyond ventral; the posterior margin oblique and much within that of ventral, with a strong plait running from the lower angle of apex to the margin of ventral. Cells large, orbicular, double-walled, with minute cellules in their angles. Stipule large, sub-orbicular (in outline), 1½ lines diameter, 4-fid, sinuses very broad, the two inner segments largest, much lacinio-ciliate; ciliæ very long, flexuous, brownish-olive coloured, 10-celled, branched, their bases 2-celled laterally within ciliæ; cells oblong, narrow.

Hab. On the ground, low damp woods, banks of river, south of Dannevirke, County of Waipawa; 1888: *W. C.*

3. *G. longiseta*, sp. nov.

Plant gregarious, procumbent, ¾in.–1in. long, broadly triangular (in outline), tip acute, pinnately branched at base; branches short, spreading. Stems stout, sub-succulent, leafy to base, thickly and coarsely matted below with dark-red rootlets. Leaves yellow-green, closely imbricated above, distant and smaller below, all margins laciniate-serrate, laciniæ flexuous; ventral lobe 3 lines long, triangular-ovate, strongly plaited at lateral junction of dorsal lobe, the plait laciniate; dorsal lobe much smaller, and within both margins of ventral, tip oblique, acute, base rounded, sub-dimidiate-cordate; perichætial leaves larger and broader, much and irregularly laciniate. Fruit-stalk 1¼in. long, slender, flexuous; capsule red-brown, linear-oblong, 2½ lines long; valves 2 lines long,

* Here please observe and correct an error—or, rather, two errors—in vol. xix., "Trans. N.Z. Inst.," pp. 284, 285, where two new species of *Gottschea* described by me are both specifically named "*compacta*." And what makes it still worse is the fact that in vo. xvi., p. 349 (same work) is another new species of *Gottschea* also named "*compacta*." How that error occurred in vol. xix. I do not know, but the species described on p. 284 should have been specifically named *laciniosa*, and that on p. 285 *gregaria*, which names please substitute for those thus erroneously given.

linear, minutely striate, tip sub-mucronulate. Stipule very large (for plant), sub-quadrate, 2½ lines wide, slightly bifid, sub one-fourth from tip, laciniate-serrate. Cells large, of various shapes and sizes, orbicular to narrow oblong, their walls double.

Hab. On rotten logs among ferns, where it forms large spreading patches, low woods near Dannevirke, County of Waipawa; 1888: *W. C.*

4. *G. heterodonta*, sp. nov.

Plant gregarious, light-green, sub-procumbent; stems and branches stout, succulent, 1in.–1¼in. high, 4–5 lines wide at top, branched above, bipinnate, branches long, spreading. Leaves distant below, closely imbricated above, half-clasping, ventral lobe oblong-ovate, tip acute, sharply cut serrate, a thick plait from tip of dorsal, with small short plaits running to margin, and all the plaits denticulate on the under side of lobe; anterior margin slightly toothed; posterior margin laciniate-serrate; dorsal lobe, anterior base arched, produced, denticulate, the bases overlapping each other on stem; tip sub-truncate, toothed; the posterior margin curved, thick, coarsely denticulate, and much within the margin of ventral. Cells large, oval, walls thick. Stipule broadly hippocrepiform, 1½–2½ lines wide, narrowest at base, bifid half-way down, lobes truncate, tips trifid, margins coarsely laciniate all round, each lobe with 5–10 broad laciniæ; sinus broad, rounded at base.

Hab. On rotten logs, woods near Dannevirke, County of Waipawa; 1888: *W. C.*

5. *G. steno-carpa*, sp. nov.

Plant bright yellow-green, gregarious, semi-prostrate and sub-erect; stems very stout, 1in.–1½in. long, forked at top, branches short, 4–5 lines wide; main stem narrower, with rootlets at base. Leaves close, imbricate, wavy, 3½ lines long; ventral lobe semi-ovate, serrate, tip acute, with one short plait running from tip of dorsal lobe towards margin of ventral; anterior margin, the basal portion coarsely laciniate-serrate; posterior margin nearly entire, with 1–2 small distant teeth, bases overlapping on stem; dorsal lobe, tip narrow, truncate, with a long curved tooth at the upper angle; anterior margin somewhat coarsely serrate; posterior margin curved slightly within ventral, coarsely toothed. Involucral leaves erect, narrow oblong, largely laciniate; laciniæ wavy. Stipule bifid, laciniate. Cells large, clear, oblong, double-walled. Fruit-stalk slender, 1½in. long. Capsule narrow linear, cylindrical, 3 lines long, brown; valves linear ligulate, sub-acute, with numerous broad longitudinal dark lines, and closer finer lateral ones; cells quadrate.

Hab. On ground, forming large compact turf-like patches, low woods near Norsewood, County of Waipawa; 1886: *W. C.*

6. *G. mitteniana*, sp. nov.

Plant gregarious, pale, prostrate; stem thick, succulent, hairy beneath, with dark-red wiry rootlets in small detached bunches at bases of stipules, simple, sometimes once-branched near top, 1in.–1¾in. long, 4 lines wide at top, oblong-ovate. Leaves amplexicaul above on stem, imbricate, dorsal bases largely overlapping and wavy, distant and smaller below; ventral lobe sub-oblong-ovate (lingulate), the apical half serrate, having 2–3 small laciniations on each side with thick diagonal plaits, tip obtuse, minutely sub-apiculate, the basal half of anterior margin produced, ciliate; ciliæ long, flexuous, branched; the posterior margin finely serrulate; dorsal lobe short, sub-trapeziform, truncate; anterior margin closely and finely serrulate, increasing at tip; posterior margin straight, distant from that of ventral lobe. Cells large, rather coarse and irregular, sub-orbicular and broadly elliptic. Stipule large, sub-flabelliform-quadrate, 4-lobed, sinuses deep narrow sub-acute, very much ciliate on all sides; ciliæ long, flexuous. Numerous stipellæ (phyllodia?) in the axils, the largest sub-quadrate, bifid, tips truncate; the others narrow linear, and all largely and finely ciliate.

Hab. On ground at bases of trees, low wet woods, Norsewood, County of Waipawa; 1886: *W. C.*

Obs. A species somewhat resembling *G. balfouriana*, Hook. f. and Tayl., in general appearance, but leaves without lamellæ, and the whole plant much more ciliate, the ciliæ longer, flexuous and cellular; the basal anterior margin of leaf finely ciliate, and the phyllodia more numerous and hairy-ciliate.

7. *G. moniliformis*, sp. nov.

Plant gregarious, prostrate, obovate-oblong, ¾in.–2in. long, 4 lines wide at top, slightly branched, leafy to base, stem stout, dark-coloured, for three-fourths of length beneath covered with dense blackish-purple rootlets. Leaves close, much imbricated above; ventral lobe narrow ovate, obtuse, with two plaits running to margin from angles of tip of dorsal; the tip and apical half of anterior margin serrate, the basal half ciliate; the posterior margin entire; dorsal lobe short, three-fifths of ventral, tip truncate, broad, and toothed; anterior base rounded, produced beyond ventral and largely overlapping stem, with a few distant minute marginal teeth and 2–3 fine plaits, slightly denticulate on lateral line of posterior margin. Cells large, sub-orbicular, sometimes oval, clear, their walls broad and double, with minute cellules. Stipule

sub-flabelliform-orbicular, narrowest at base, deeply bifid (half-through) or quadrifid, the two outer lobes being smaller; sinuses large, round; all sparingly (4–5) lacinio-ciliate, the lower sides of stipule with usually one straight, horn-like cilia on each; ciliæ very long, straight, acute, peculiarly moniliform or strangulated, their alternate cells wanting or reduced to a fine black thread. Cells of stipule large, oblong, clear, their walls thick, larger at margins and at bases of ciliæ. In the axils between lobes 3–5 small patent stipellæ (or phyllodia), each 3–4 laciniato-branched.

Hab. Woods, Great Barrier Island, Frith of River Thames; 1888: *Mr. C. P. Winkelmann.*

8. *G. epiphyta*, sp. nov.

Plant prostrate, creeping, flaccid, pale-green. Stems simple, and sparingly dichotomously branched, linear, 2in. long, 3–3½ lines wide, leafy throughout, adhering its whole length beneath by its numerous dark-red rootlets. Leaves rather distant below, close and sub-imbricate above; ventral lobe narrow oblong, sub-acute; anterior margin serrate, with an auricle at base cilio-fimbriate, several plaits in the apical half, the two larger ones from below tip of dorsal lobe, running diagonally to a notch in each margin, the largest broad and raised, its edge denticulate; posterior margin serrate with a few notches, base ciliate; dorsal lobe semi-cordate, serrate, tip broadly truncate, coarsely serrate, base ciliate; anterior basal portion much rounded and produced far beyond ventral lobe, slightly overlapping on back of stem; posterior margin considerably within that of ventral. Cells large, sub-orbicular, irregular, compact, thick-walled with minute cellules. Stipule very large, sub-oblong-quadrate, 4–5-fid, cut half through, sinuses rounded, lobes large oblong, tips truncate, margins sinuate, much ciliate; ciliæ long, flexuous, curly, 2-celled at bases and springing from marginal knobs; a row of ciliæ down centre of stipule from base of sinus; cells as in leaves, but coarser. Several small stipellæ (phyllodia?) of finely-curved fimbriæ in the axils of leaves.

Hab. On trunks of tree-ferns, growing downwards, low wet forests near Norsewood, County of Waipawa; 1886: *W. C.*

9. *G. winkelmannii*, sp. nov.

Plant large, prostrate, horizontal, flat, narrow oblong or sub-oblong-lanceolate, 3in. long, 9 lines wide, tip broad, tapering and leafy to base, usually simple—a few specimens seen 1-branched about the middle, with numerous long pink rootlets from the middle and base of the stem. Leaves pale-green, membranous, imbricate; ventral lobe 4 lines long, sub-oblong-lanceolate, tip acute, the upper portion

(both sides) deeply laciniate and finely toothed, the basal anterior margin distantly lacinio-ciliate, their sinuses broad and curved, the basal posterior margin entire; dorsal lobe half as long, tip acute, its basal anterior margin much arched, produced beyond margin of leaf and very minutely serrulate, sub-auricled and largely overlapping on stem, auricles sub-erect and recurved; the posterior margin considerably within the margin of the ventral lobe; both lobes a little plaited diagonally. Cells of various sizes, oblong-orbicular not clear, walls thick, smaller and distinct at margins. Stipule large, orbicular (in outline), 2 lines diameter, bifid two-thirds of depth, the basal portion plaited, each segment truncate, sub-tripartite (2-lobed on the outer and 1-lobed on the inner margin), edges recurved, largely lacinio-ciliate; laciniæ curviform; sinuses large, rather broad, their laciniæ and ciliæ crossing each other and them. Cells oblong-orbicular, clear, their walls very thick.

Hab. On rotten wood, forests, Great Barrier Island, Frith of Thames; 1888: *Mr. C. P. Winkelmann.*

Obs. A fine species, having affinity with *G. appendiculata*, Nees, but differing in several particulars, as in size, habit, short stipe, and being leafy to base; the leaves narrower and plaited; the ventral lobe having shallower laciniæ in the upper portion, and deeper and curved ones in the lower anterior margin; the dorsal lobe more produced, minutely serrulate, and auricled; the stipules, also, larger, more divided, and lacinio-ciliate.

Genus 8. **Chiloscyphus**, Corda.

§ 1. Leaves opposite, stipules united to both the leaves below them.

1. *C. epibrya*, sp. nov.

Plant large, creeping, 3in.–3½in. long, 2¼ lines wide, simple and branched, usually 3-branched at top, and sometimes these again slightly forked at tip, leafy throughout, very membranous, pellucid, delicate pale-green. Leaves opposite, close, imbricate, patent, sub-trapeziform, very broad at base, narrowly decurrent, long and diagonal on dorsal surface of stem, tip truncate with one horn at each outer angle, the horns 4-celled, spreading, the sinus sub-sinuate and slightly produced not incised, margins delicately thickened. Cells pentagonal and sub-orbicular, with large clear double walls, and narrow linear interstitial cellules. Stipules large, sub-orbicular, 6-toothed, teeth large, connate with leaves below, the base of stipule hollow and rounded, with many fine rootlets.

Hab. Overrunning mosses, on the ground, wet thickets, Taupo, and interior.

Obs. A species allied to *C. colensoi*, Mitten ("Handbook N.Z. Flora," p. 753).

2. *C. spruceana*, sp. nov.

Plant prostrate, creeping, 1½in.–2in. long, 2 lines wide, very pale-green; simple and with 1–3 short lateral branches; the under surface of stems clothed with very fine rootlets. Leaves opposite, close, imbricate, patent, 1 line long, sub-trapeziform or broadly pyramidal with the apex (one-fifth) cut off, very truncate, straight or slightly sinuate, 2-ciliate-horned, one at each outer angle, margined; margins entire and straight; very broad at base, decurrent. Cells very large, sub-quadrate-orbicular or sub-pentagonal, their walls double. Stipules large, sub-quadrate-reniform, with five (rarely six) cilio-fimbriæ, long, flexuous, subulate, 6–8-celled, the two lower cells geminate; connate rather broadly on both sides with leaves. Sinuses very large and broad at base.

Hab. Growing over and closely adhering to patches of *Lepidozia leucocarpa* (*infra*), low woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. The outline of leaf resembles that of *Lophocolea ciliata*, Mitt.

3. *C. ammophila*, sp. nov.

Plant prostrate, spreading, dichotomously branched at top, 1½in.–2in. long, 3 lines wide at middle of main stem, 2 lines on branches, dusky dark-green, but when young light-green. Leaves imbricate throughout, deltoid-rotund, dimidiate, very wavy, shining, entire, margined, with a strongly-marked horizontal green line running towards apex; tip rounded, obtuse and sub-acute; decurrent on dorsal stem and meeting at their extreme bases. Cells sub-orbicular, walls double with minute cellules, oval and larger at centre. Stipule large, connate on both sides, reniform, concave, recurved, ciliate-toothed; teeth few, distant, smaller at the ends.

Hab. On the ground with other small plants, sandy spots, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

4. *C. vulcanica*, sp. nov.

Plant small, sub-erect, simple and forked at base, sub ½in. high, $\frac{1}{20}$in. wide. Leaves very close, slightly imbricated, regular, spreading, sub-deltoid, apex truncate straight, 2-horned (the upper one generally longer and curved), dimidiate, sides slightly rounded, irregularly ciliate-toothed, teeth straight; ventral margin produced at base and more ciliate, ciliæ curved. Stipule large (for plant), oblong-quadrate, retuse with ten long teeth, six at top and two at each side, connate with leaf below on both sides; margined, edges and

tip coloured brown. Cells large, clear, sub-orbicular with a central bead, and minute cells in the angles.

Hab. Among other *Hepaticæ* and low mosses, on the ground, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

5. *C. marginata*, sp. nov.

Plant pale, prostrate, creeping, 2in. long, stems 1¼ lines wide, simple, and forked at tips. Leaves very membranous, sub-opposite, close, half imbricated, margined, sub-rotund-quadrate above on stem, deltoid, below their bases very broad; tips broad, emarginate and obtuse, wavy, recurved, decurrent and slightly diagonal on dorsal surface of stems, with their extreme ends overpassing. Cells compact, orbicular, dotted each with 2-5 spots, walls narrow but double with minute interstitial cellules. Stipules bifid, margins uneven; lobes long, acuminate, flexuous, with two long laciniate flexuous teeth on each outside near base; connate with leaf, largely amplexicaul. Sinus very large, sub-acute, spreading, with sometimes a tooth, and many small white rootlets from base.

Hab. On ground, among mosses, wet woods, Taupo.

§ 3. Leaves opposite or alternate, stipule free.

6. *C. venustula*, sp. nov.

Plant small, delicate, horizontal, creeping, 1in.-2in. long, scarcely 1 line broad, simple, and slightly branched near base; stems dark-coloured, wiry, rooting under each stipule. Leaves darkish, clear, pinnate, sub-opposite, sub-quadrate, adnate, detached not imbricate, the apex broadly rounded with three equidistant spiny ciliæ, which are two-fifths length of lamina, straight and celled. Cells large, sub-orbicular, clear. Stipule small, free, of three spreading rays, celled. Fruit not seen.

Hab. Among mosses, &c., on ground, sides of Mount Tongariro, East Taupo; 1887: *Mr. H. Hill.*

Obs. An elegant little and extremely delicate species; its manner of growth serving to show to advantage its rather peculiar and striking segments, with their long, straight, outstanding ciliæ. Not having met with it in a fruiting state, it is provisionally placed under this genus, as it may prove to be a *Lophocolea;* but, from its appearance and its rooting under the stipules, I believe it to be a *Chiloscyphus*. I only obtained a few specimens, laboriously picked out from other small cryptogams, and cleaned from pumice-dust.

7. *C. insula*, sp. nov.

Plant small, gregarious, erect, ½in. high, mostly simple, sometimes one-branched, broadest at top, tips recurved; 2-3

stout flagellæ descending from middle of stem. Leaves closely imbricate, wavy, yellowish-green, broadly sub-oblong-ovate, entire, sometimes minutely, distantly, and irregularly denticulate. Stipules narrow reniform-oblong, contracted at base, sub-amplexicaul, margins irregular, slightly and distantly toothed. Cells large, orbicular, dotted, with minute cellules in their angles. Perianth basal, shortly peduncled, green, campanulate; mouth lacinio-ciliate, flexuous; involucral leaves—inner, small, entire; outer, erect, trifid.

Hab. On rotten wood, among mosses, forming spreading patches, forests, Great Barrier Island, Frith of Thames; 1888: *Mr. C. P. Winkelmann.*

8. *C. lingulata*, sp. nov.

Stem procumbent, creeping, simple, straight, 1in.–2½in. long, 3 lines wide (in the larger specimens), spreading and growing over each other, stoutish, brown, shining, pinnatifid; lobes (or leaflets) of two sizes on stem, the lower being much smaller; cut nearly to rhachis (sometimes distinct), adnate, scarcely decurrent, alternate and sub-opposite, sub-imbricate, oblong-lingulate, entire, both margins nearly straight, the lower slightly oblique; tips rounded, very obtuse, with occasionally a very minute microscopical tooth or horn at the anterior apical corner; the segments in the small branches having their tips more truncate, and often minutely 2-horned, one at each of the outer angles; pale whitish-green. Cells large, compact, sub-quadrilateral, with free, thickish, dark rings within them. Stipules rather large, spreading, distant, bifid; tips acuminate, acute; sinus broad, the base rounded, each lobe 3–4 denticulate-ciliate; generally placed centrally under the upper lobe of a quasi pair of leaves, and sometimes at their junction on stem. Cells large, orbicular, clear, with a thick bunch of long flexuous white rootlets at base of each stipule. Perianth peduncled on ventral side near base, 4–5 pairs opposite and near each other, short, stout; perianth green, lobes long acuminate, laciniate, curved.

Hab. On the ground, damp shady forests near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species having close affinity with *C. supinus*, Hook. f. and Tayl., and also with *C. polycladus*, Mitt. This peculiarity of its leaves being biformed, and bidentate on the smaller (or younger) branches, has also been noticed to obtain in the allied form *C. supinus*—viz.: "in ramis junioribus folia abnormalia varie bidentata" ("Fl. Nov. Zeal.," vol. ii., p. 142).

9. *C. epiphyta*, sp. nov.

Plant small, delicate, simple, and forked, ¾in.–1in. long, 1 line wide, pale-green. Leaves close, scarcely imbricate,

sub-oblong-quadrate, broadest at base, tip truncate, with a long cilia-like spreading tooth at each angle (sometimes, also, a similar tooth in the middle of sinus), sinus excised, irregular, broad and deep, margin entire; anterior margin slightly arched, and depressed near tip; posterior margin straight. Cells large, orbicular, walls double with connected linear cellules. Stipules free, small, largely bifid; lobes long, flexuous, recurved, spreading, each with 3–4 basal longitudinal geminate cells, and two small teeth on the outside; sinus very large. Perianth sessile, erect, often two together near base, campanulate; tips largely laciniate, recurved. Calyptra globose, urceolate, mouth laciniate. Fruit-stalk 8–9 lines long; valves oblong, obtuse, brown.

Hab. On trunks of tree-ferns (*Dicksonia* sps.), low wet woods near Norsewood, County of Waipawa; 1886: *W. C.*

10. *C. montana*, sp. nov.

Plant small, prostrate, simple, linear, flexuous, very delicate, sub ½in. long, 1 line broad. Leaves sub-opposite, close, oblong-quadrate, sides straight entire; tips truncate, irregularly ciliate-toothed; teeth 2–5 (usually 4), straight, spreading. Cells large, clear, oblong-hexagonal, regular in almost lateral bands. Stipule small, free, broadly ovate, bifid; lobes acuminate, forked; sinus large, rounded; ciliate, ciliæ few; cells as in leaves.

Hab. On ground with other small *Hepaticæ*, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. This plant in its young state is whitish pellucid, leaves with fewer and more distant teeth; when aged it is longer, dark-brown, more flexuous and sub-rigid, with its leaves more distinct: unless these, from more copious and better specimens, should form two species.

11. *C. heterodonta*, sp. nov.

Plant prostrate, stems stout, about 1in.–1½in. long, lanceolate, 2 lines wide at middle, simple, and branched at base. Leaves green, sub-imbricate at middle of stem, oblong-quadrate; tips bifid (sometimes irregular) and much ciliate; lateral margins entire, but some leaves have one long ciliate tooth at the middle of the anterior lateral margin, or (but more rarely) one on the posterior margin. Stipule minute, free, narrow ovate, bifid, and sometimes trifid, with six ciliæ, three on each side. Cells large, clear, oblong-hexagonal.

Hab. With preceding, *C. montana*, Col.

Obs. This plant possesses several characters in common with *C. montana*, while it differs in others, which are also constant. Better specimens are wanting. I picked out both from a quantity of broken vegetable *rejectamenta.*

12. *C. compacta*, sp. nov.

Plant small, sub-erect, $\frac{3}{4}$in.–1in. long, $1\frac{1}{2}$ lines wide, mostly simple, sometimes 2–4 branched; branches short, tips recurved, leafy throughout; pale-green. Leaves sub-opposite, closely (one-third) imbricated above, less so below, sub-rotund and sub-orbicular-quadrate, margined, entire; tips broad, sub-sinuate, and slightly sub-emarginate. Cells large, orbicular, clear, with minute cellules in their angles. Stipules small, free, distant from bases of leaves, broadly ovate, 4-laciniate toothed; teeth flexuous, sharp, a middle one very long.

Hab. On the ground in wet woods in the interior, Taupo, &c., forming pretty large compact patches.

13. *C. dicyclophora*, sp. nov.

Plant small, sub-erect, $\frac{3}{4}$in.–1in. long, $\frac{1}{2}$ line wide, simple, and slightly branched; of a pleasing green, with yellow recurved tips. Leaves densely imbricate, recurved, semi-rotund; anterior margin arched and with apex toothed, 10–12 blunt teeth; posterior margin produced at base, forming a complete circular dot-like auricle, which is doubled. Cells large, orbicular, walls thin with minute interstitial cellules in angles, also obscurely beaded. Stipules distant, narrow (sub-linear), reniform, clasping, with a hollow circular centre showing the stem, their ends free, obtuse, each terminating in a complete circular dot like those of leaves. Perigonial leaves, near base, sub-flabellate, erect, toothed, with linear, brownish, antheridia in threes, within a sub-campanulate receptacle with fringed margins.

Hab. Low wet woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A curious and pretty plant, nearly allied to *C. cymbaliferus*, Hook. f. and Tayl.

Genus 11 (1). **Tylimanthus**, Mitten.

1. *T. novæ-zealandiæ*, sp. nov.

Plant gregarious; root creeping, long, stoutish, simple, naked. Stems sub-erect and drooping, 3in.–4in. high, simple, and few-branched; stipe 1in. long, bare below, with distant small leaf-like scales on its upper part; branches long, $1\frac{1}{2}$in.–$2\frac{1}{2}$in. (sometimes two together from one base), 4–5 lines wide, linear, drooping, leafy throughout; pale yellowish-green. Leaves alternate, pinnate, very membranous, wavy and obliquely set, distant and small on lower part of branch, increasing in size upwards, close above, and sub-imbricate in middle of branch, semi-cordate-ovate, dimidiate, 3 lines long, 2 lines wide at broadest part near base, with several small marginal plaits; decurrent on dorsal side, their basal ends crossing; margins finely serrated, the basal portions entire,

that of anterior margin much rounded, of the posterior straight; tips sub-truncate, retuse and very obtuse. Cells obscure. Involucre terminal, between two small narrow sub-vertical leaves, on a short simple stem, nodding, affixed by its base, cylindrical, 3½ lines long, 1 line wide, glabrous, or finely and sparingly pulverulent; light-brown.

Hab. On the ground in wet spots, low woods, near Norsewood, County of Waipawa; 1886: *W. C.*

Obs. This is our largest (known) New Zealand species, and is also very distinct. Its larger leaves when flattened have a peculiar outline, closely resembling the profile of a large dog's head (setter); the retuse portion near the posterior margin, with its plait, forming the mouth, and a larger plait the eye.

Genus 11 (4). **Balantiopsis**, Mitt.

1. *B. glandulifera*, sp. nov.

Plant prostrate, horizontal, flat, spreading, 1½in.–2in. long, 2 lines wide, slightly irregularly branched; stems thickish, rooting at stipules; rootlets long, flexuous, white and purplish; branchlets ¾in. long, pinnate, leaves nearly free, slightly imbricate, pellucid, pale, pinkish at tips, as also at stipules, broadly elliptic, obtuse; posterior margin crossing above on stem, laciniate lobed; sinuses broad, sub-margined, ciliate; ciliæ obtuse, celled, two cells wide at base. Stipules sub-flabellate in outline, 5-fid, laciniate-ciliate. Cells large, oblong-hexagonal and parallelogrammical, sub-orbicular at margins. Torus pendulous near apex, oblong, cylindrical, obtuse, 1–1½ lines long, hairy; hairs short, purple-pink, glandular, with globular dark-pink tips.

Hab. Among other *Hepaticæ* on the ground, Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. An interesting little species, having affinity with *B. (Gymnanthe) diplophylla*, Mitt., but differing in several characters. I have only detected two fruiting specimens: like other allied species and genera,* fruiting specimens seem to be very rare.

Genus 11 (5). **Marsupidium**, Mitt.

1. *M. epiphyta*, sp. nov.

Rhizome creeping. Plant gregarious, small, delicate; stems simple, forked and branched at bases, 6–8 lines long, 1 line (or less) wide, linear, flexuous, prostrate. Leaves pinnate, sub 20 jugate, alternate, distant, adnate, decurrent, sublinear-spathulate, broadest at top, the lower ones very minute sub-oblong-quadrate, margins slightly uneven; the anterior margin arched, the posterior straight; tips bifid, lobes irregu-

* "Trans. N.Z. Inst.," vol. xix., pp. 286, 287.

lar acuminate, sharp, the upper one larger; sinus broad, with several very minute teeth on lobes and anterior apical margin. Cells (in young leaves) small, compact, sub-orbicular, walls thick with cellules in them; in old leaves obscure and beaded. Involucre at bases and at forks of branches, small, triangular-ovoid, 1 line long, brownish, glabrous, hairy at top, with a few scattered hairs below; hairs white.

Hab. Epiphytical on trunks of tree-ferns, low wet woods near Norsewood, County of Waipawa; 1885: *W. C.*

Obs. A species very near to (?)*Tylimanthus perpusillus*, Col. ("Trans. N.Z. Inst.," vol. xix., p. 286).

Genus 13. **Lepidozia**, Nees.

1. *L. elegans*, sp. nov.

Plant small, pale, slender, delicate, creeping, ¾in. long, ½ line wide, simple, and pinnately branched; main stem stoutish for size of plant, with straight longitudinal lines and cells; branches alternate, irregular, 3–4 lines long. Leaves alternate, close but not imbricate, horizontal, oblong-quadrate, sides straight, entire, tips truncate 3-ciliate; ciliæ three-fourths of length of leaf, subulate, acute, straight, extended, 4-celled; their sinuses rather broad and bases subangular. Cells large, sub-quadrate, distinct, walls thick, usually disposed in 6 lines with 6 cells in a line—sometimes, but rarely, less. Stipules minute, 3-rayed, with a dark-coloured knot or node, and fine short rootlets.

Hab. On rotten wood, forests, Great Barrier Island, Frith of Thames; 1888: *Mr. C. P. Winkelmann.*

Obs. I. An elegant and curious little species, pretty closely allied to *L. centipes*, Tayl. (a Tasmanian plant), with which it may easily be confounded at first sight, but differing from that species in many characters, as in the main stem having differently-formed and longer cells; in the leaves having a less number of cells, with *no long basal cells* (double size), which are so very conspicuous in *L. centipes*, and only three (not four) ciliæ, with their bases usually single-celled; and in the stipules being 3- (not 4-) rayed.

II. In the very full and clear description of *L. centipes* given by Lindenberg and Gottsche ("Species Hepaticarum," pp. 29, 30), they say: "Folia . . . . quadrifida fere ad medium; laciniæ sub-rectæ, quaternis cellulis, singula serie dispositis, binisque fultis constant. . . . . Cellulæ foliorum basales reliquis fere duplo longiores unde singularem adspectum, cum aqua non cito penetrentur, præbent." Which their accompanying drawing and dissections also clearly show.

2. *L. leucocarpa*, sp. nov.

Plant very small, densely tufted, main stem creeping, ½in.-

$\frac{1}{4}$in. long, branched; branches 1–2 lines long, erect, close, opposite and alternate, flexuous, simple forked and pinnate, few-leaved. Leaves 3-fid, lobes long, subulate, and spreading, 5–6 celled; lamina very short, 2 cells deep, cells narrow linear. Perichætial leaves larger and broader, ovate, tip laciniate. Stipule closely resembling leaves, only smaller in size. Perianth terminal and basal, large for plant, 2 lines long, whitish, lanceolate, plaited above, cells linear, parallelogrammic, clear; mouth lacinio-fimbriate (usually twelve fimbriæ, their cells very long). Fruit-stalk $\frac{1}{4}$in. long. Capsule small, brown-red; valves sub-linear-lanceolate, margined, obtuse, with longitudinal parallel stout dark lines, and latitudinal fine brown ones; cells narrow parallelogrammic.

Hab. On the ground in low wet woods, forming thick spreading patches, near Norsewood, County of Waipawa; 1885: *W. C.*

Obs. A very peculiar-looking and striking little species, from its numerous long white perianths, which are very conspicuous owing to their erect position above the plant, their size, and colour.

3. *L. minutissima*, sp. nov.

Plant very small, exceedingly slender, 1in.–2in. long, $\frac{1}{40}$in. broad, prostrate, creeping, bipinnate, much branched; branches alternate, irregular, some very long for plant, and some ending with flagellæ; pale-green when fresh, but of a light-brown afterwards. Main stem (and flagellæ) translucent, composed of longitudinal parallelogrammic cells. Leaves distant on main stem, close together and patent on branches and branchlets, 3-rayed, cut nearly to base, the minute lamina composed of two small cells; segments capillary, sub-articulate, acute, spreading, 6-celled, the lowermost geminate. Stipules similar but smaller, with fine white rootlets descending from their bases.

Hab. On rotten logs among other *Hepaticæ*, particularly *Gottschea* sps., creeping between and over its leaves; forests near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A peculiar and minute, almost microscopical, plant; its known affinities are with *L. lindenbergii*, Gottsche, and *L. capillaris*, Lind.

Genus 14. **Mastigobryum.**

1. *M. heterodontum*, sp. nov.

Plant creeping, 2in.–3in. long, $1\frac{1}{2}$ lines broad, stout, leafy to base, dichotomous; branches spreading at right angles; flagellæ stout, short. Leaves brownish-green, thickish, opaque, closely imbricated, sub-trapeziform, very broad at base, dimidiate, truncate, falcate, recurved, 3-fid, teeth

irregular (and so sinuses), long and short, acute and blunt, margins sub-repand with minute denticulations about apex; anterior margin much arched; posterior nearly straight, a little excised. Cells sub-orbicular-oblong, distinct, guttulate, obscure. Stipules patent, recurved, sub-quadrate, broadest at base and closely approaching bases of leaf but not joined, top truncate, sub 4-fid, each coarse tooth (or small lobe) again serrate, sides denticulate. Cells narrow oblong and clear at margins, smaller and more compact (yet distinct) at centre and base.

Hab. Woods near Lake Waikare, County of Wairoa; 1888: *Mr. H. Hill.*

Obs. Only three specimens received, mixed with other *Hepaticæ.*

2. *M. vulcanicum*, sp. nov.

Plant stout, dichotomously branched, (?) 2in.–3in. long, 1½ lines wide, dark-coloured, flagelliferous; flagellæ wiry, rigid, branched. Leaves brown, thickish, rather opaque, falcate, close-set, narrow oblong, broadest at base, with their slightly-produced anterior margins near base a little overlapping; tips truncate with many acute teeth, the three principal ones large and sub-spiny; the lateral margins slightly denticulate below apex; anterior margin a little arched; the posterior one slightly incurved, and excised at an obtuse angle near base. Cells distinct, guttulate in longitudinal lines, alike throughout. Stipules distant, sub-quadrate, much recurved, their tips and sides largely and irregularly toothed inclining to spiny.

Hab. Among small tufts of other *Hepaticæ* and mosses, on the ground, Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. A species near to *M. olivaceum*, Col. ("Trans. N.Z. Inst.," vol. xix., p. 290).

3. *M. smaragdinum*, sp. nov.

Stems rather stout, cellular, 1in. long, sub-flabellately branched; branches forked, pinnate, very leafy throughout, much flagellate; flagellæ flexuous, stout, scaly. Leaves dark grass-green, shining, numerous, imbricate, oblong, dimidiate; tip 2-lobed, the upper lobe larger, sinus wide; margins entire but slightly uneven, the anterior one arched excised at apex, the posterior nearly straight. Cells large, very regular, sub-orbicular with minute interstitial orbicular cellules at their angles, oblong and a little larger at extreme base. Stipule free, distant, appressed, sub-quadrate, 3-fid, lobes stout, obtuse; cells as in leaves. Male inflorescence near base of stem, pedicelled, 4–5 nearly together; perigonial leaves very

cellular, forming a narrow cup, sharply laciniate, white with pinkish bases, enclosing 8–10 sub-cylindrical sacs.

Hab. Among other *Hepaticæ* and overrunning them, on decaying logs; woods south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species very near *M. colensoanum*, Mitt., but differing in colour, and in form of leaves, stipules, and cells: also, near to *M. amœnum*, Col. ("Trans. N.Z. Inst," vol. xix., p. 288), but differing in colour and position of leaves, and largely in form of stipules and of cells. A very pleasing little species.

Genus 16. **Isotachis**, Mitten.

1. *I. elegans*, sp. nov.

Plant small, erect, ¾in.–1in. high, stem short irregular simple and 1-branched with innovations; leafy throughout; the leaves larger close and imbricate at top, smaller and more distant below; green when young, reddish mature. Leaves sub-oblate-orbicular (in outline), the top almost bifid, and two large shallow lateral sinuses, margins irregularly and distantly lacinio-denticulate; teeth coarse and variable. Stipules sub-quadrate, bilobed, the sinus reaching nearly to the middle and very broad (larger than lobes), extending quite across, the two corners prominently horned and directed outwards; base sub-cordate and sub-amplexicaul; margins irregularly and slightly distantly denticulate. Cells large, clear, and sub-elliptic, their walls double.

Hab. On the ground among other small *Hepaticæ* and *Schizæa australis*, sides of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. A pretty species, nearly allied to a Tasmanian one—*I. gunnii*, Hook. f.

2. *I. montana*, sp. nov.

Plant small, tufted, reddish-brown, erect, ¾in.–1in. high, very slender, simple, sometimes forked at base; stem flexuous, with 2–3 innovations, tips nodding, hairy about bases. Leaves alternate, distant (close and imbricated at innovations), orbicular-quadrate (outline), 3-fid; lobes short, triangular, acute, concave, recurved; sinuses broad, margins sub-sinuate, sometimes a few minute blunt teeth at basal portion. Cells small, compact, orbicular, with minute cellules between them, larger and parallelogrammatic at centre and base. Stipule free, between leaves, small, sub-orbicular, bifid, margins more irregular, with a few minute teeth.

Hab. Among other *Hepaticæ* and small mosses, on the ground, slopes of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

3. *I. mitteniana*, sp. nov.

Plant pale whitish-brown with a slight tinge of green; sub-erect, 2in.–2½in. high, loosely branched; branches long, simple, and sparingly pinnate, 2 lines wide. Leaves opposite, close, sub-imbricate above, broadly triangular or semi-rhomboidal (smaller at bases), slightly decurrent; tips acute, recurved, irregularly ciliate. Perichætial erect, oblong, ciliate, tips rounded. Stipules large, distant, sub-oblong-quadrate or broadly reniform, sub-margined, patent, convex much recurved, amplexicaul, largely ciliate (sub-cilio-fimbriate); ciliæ broad at base, flexuous, cellular; sinuses large, round. Cells small, sub-orbicular, with minute interstitial cellules, much larger oval and oblong at centre and base. Perianth tubular, 2½ lines long, trigonous, edges undulate with double teeth, mouth lacinio-ciliate. Fruit-stalk 1¼in.–1½in. long; capsule rather small; valves oblong-lanceolate, margins slightly uneven, tips obtuse.

Hab. Among other *Hepaticæ*, wet forests near Norsewood, County of Waipawa; 1885: *W. C.*

Genus 18. **Sendtnera**, Endlicher.

1. *S. quadrifida*, sp. nov.

Plant sub-erect, 2in.–3in. high, with 2–3 main stems from base, each bi- sometimes tri-pinnate, light-green; branches alternate, distant, simple and forked, deflexed, the few lower ones with their tips drawn out and sub-flagellate; the tops of the upper ones and of the main stems sub-glomerate, from their numerous compacted leaves, recurved and nodding; tips reddish. Leaves erect, sub-appressed, imbricate on branches, ½ line long, narrow oblong, sides straight and largely lacinio-ciliate, quadrifid, or bifid with each of the two main lobes deeply divided; lobes acuminate, wavy, spreading, their margins slightly uneven; sinuses sub-acute, large and deep, extending two-fifths of leaf. Stipules similar to leaves, but smaller. Cells distinct, guttulate in longitudinal and parallel lines, small, sub-orbicular and elliptic, larger and more oblong at base. Fruit not seen.

Hab. Among mosses and low herbage on the ground, high hills at Lake Waikare, County of Wairoa; 1888: *Mr. H. Hill.*

Obs. This is a peculiar-looking little plant, especially in its dry state, being then sub-rigid, and somewhat resembling the branches of the smaller states of *Lycopodium densum*, Labill., its leaves and stipules presenting a quadrifarious appearance. It is, however, allied to *S. scolopendra*, Nees, and to *S. flagellifera*, Nees, but differing from both in habit and in colour, and in several characters.

Genus 19. **Polyotus**, Gottsche.

1. *P. prehensilis*, sp. nov.

Plant several inches long, much spreading, sometimes pendulous, emerald-green, branches alternate, very long, irregular, narrow and graceful, 3-pinnate; branchlets numerous, ¼in.–½in. long. Leaves on main stem semi-pellucid, deltoid-cordate, amplexicaul, their edges uneven, sub-margined with a regular compact row of small cells, dimidiate, oblique, sharply apiculate; the anterior margin much arched, with 1–2 subulate teeth near base, the base much produced and largely laciniate; laciniæ spreading, ciliate; ciliæ almost forming a little tuft, very long and spreading, flexuous, cellular, their cell-joints double; auricles free, clavate, erect, sometimes two together, with 1–2 small subulate stipellæ: leaves on branches much smaller, oval and broadly ovate, apiculate, and less ciliate. Stipules on main stem large, oblong-quadrate, auricled, deeply quadrifid, their sinuses wide and rounded at bases, conniving at tips, largely lacinio-ciliate all round, flexuous; ciliæ at bases long, divergent; auricles 3–5, stout; stipules on branches 4-fid, lobes long, subulate, simple, less ciliate at bases. Cells large, oblong, clear, with small hour-glass cellules laterally placed. Involucre underneath, axillary, and terminal on short lateral branchlets, oblong, erect, rough with long fimbriæ; mouth much laciniate; laciniæ acuminate, acute; involucral leaves erect, the outer broadly lanceolate, margins cilio-denticulate, apex acuminate, acute; the inner linear, their lateral margins thickened, entire, and distantly denticulate, the apex very acuminate acute, sometimes dilated and sub-truncate, and then cilio-denticulate.

Hab. On horizontal branches of living trees and shrubs, forming large irregular patches, overrunning itself largely, and frequently hanging loosely in the wind; shaded forests near Dannevirke, County of Waipawa; 1888: *W. C.*

Genus 20. **Radula**, Nees.

1. *R. xanthochroma*, sp. nov.

Plant minute, somewhat tufted, creeping, main stems 2–3 lines long, 1 line wide (including leaves), flexuous, branched, cellular; cells sub-quadrate. Leaves yellow, oblong-obovate, alternate, distant below, sub-imbricate above, larger and broader on main stems, smaller and narrower on branches, margined; lobules sub-oblong-obovate, dimidiate, scarcely half the length of leaf; involucral leaves similar to those of stem, but smaller. Cells orbicular, clear, large for plant. Perianth terminal on short branchlets, campanulate, mouth somewhat lobed; lobes thickened in the middle by a kind of ridge, mucronate.

Hab. On bark of living trees among other *Hepaticæ*, often found creeping over *Metzgeria*: edges of woods near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. Its very diminutive size and pure-yellow colour distinguish it well from all other species known to me. It is rather scarce, though from its smallness it may have been often overlooked. A similar small New Zealand species (*R. strangulata*, Hook. and Tayl.) is given in "Syn. Hepat," p. 730: discovered by Hooker in 1840, but apparently omitted by him in "Fl. Nov. Zealand.;" differing, however, from this species in several characters.

2. *R. lycopodioides*, sp. nov.

Plant erect in little tufts, very small, about 2 lines long, $\frac{1}{30}$in. wide, simple and 2–3-branched; branches and main stem all of nearly same length and size, sub-cylindrical. Leaves brownish, alternate, densely imbricate throughout, sub-rotund; tips produced over (or incised at) apex of lobule; lobule broadly oblong, tumid, rather large for leaf, being nearly half its length. Cells orbicular, small, larger at centre and base.

Hab. On branchlets of living trees among other *Hepaticæ* and mosses; woods near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A most peculiar-looking little species; differing widely from all others known to me; resembling the tiny narrow spike of a small *Lycopodium*, or a minute catkin of some amentaceous or coniferous plant.

3. *R. albipes*, sp. nov.

Plant minute, sub $\frac{1}{4}$in. long, creeping, thickly overrunning, branched, stems cellular; light-green. Leaves alternate, broadly oval, close, but not imbricate, margined; lobe obovate two-fifths of length of leaf. Perichætial erect, sub-apiculate. Cells orbicular, compact, sub-longitudinally ranged in regular lines. Perianth pedicelled, free, campanulate; mouth slightly denticulate. Fruit-stalk exserted, white; capsule orbicular, black-purple; spores oblong and linear-oblong, obtuse, one end generally broader, sometimes slightly curved.

Hab. On branchlets of *Epicarpurus microphyllus*, Raoul; and on branchlets of *Melicytus microphyllus*, Col.; woods, Dannevirke, County of Waipawa; 1888: *W. C.*

4. *R. epiphylla*, sp. nov.

Plant prostrate, creeping, 2in.–2½in. long, bipinnately branched; branches alternate, long; branchlets short. Leaves of two shapes and sizes: (1) on main stems, close but not imbricate, sub-orbicular, anterior margin and apex rounded, the posterior less so and contracted at base; (2) on smaller

branches, sub-imbricate and more oval; lobe very small, angular, sub-trapeziform, tip truncate. Cells distinct, guttulate, brownish, somewhat obscure. Perianth terminal on short lateral branchlets, between two branchlets that are divergent from base (giving the appearance of a cross); peduncled, with no proper perichætial leaves, long, oblong-cuneiform, sides straight, increasing in width to mouth, tip truncate, slightly uneven; capsule included, narrow obovate, mucronulate.

Hab. Epiphytical on fronds of *Hymenophyllum* (sps.); damp woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Genus 22. **Lejeunia**, Libert.

§ 1. Stipules 0.

1. *L. ochracea*, sp. nov.

Plant small, brownish-yellow, creeping, 1in. long; main stem flexuous, terete, shining, sub-tripinnate, much branched; branches close, very irregular in size, long and short alternately. Leaves orbicular, tapering at bases, imbricate; lobule rather large, ovate, inflated; tips truncate. Cells minute, compact, orbicular, with minute interstitial cellules. Stipules 0.

Hab. On bark of trees, mixed with and overrunning *Frullania* (sps.), woods, Norsewood, County of Waipawa; 1885: *W. C.*

§ 4. Stipules 2-fid.

2. *L. albiflora*, sp. nov.

Stems ¼in.–½in. long, creeping and ascending, much branched, often forming a small densely-implexed mass. Leaves pale-green, highly cellular (also stems), pinnate, alternate, distant, sub-sessile, spreading, wavy, slightly obovate, obtuse, margined; tips sometimes dimidiate, the anterior apical margin excised; lobule oblong-obovate, one-fifth of leaf; involucral leaves smaller, entire. Cells orbicular, punctulate. Stipules elliptic, largely bifid, tips obtuse. Peduncles numerous, terminal on short lateral branchlets, long, curved. Perianths erect, whitish, very conspicuous, campanulate, exserted free, smooth, plicate, obscurely angled at top, mucronate, 4-fid shortly cut; lobes oblong, tips obtuse, jagged, sub-mucronulate. Fruit-stalk stoutish, length of perianth; cells large, longitudinal, transversely and equi-distantly ringed with 4–5 brown bands. Capsule globular, dark-coloured; lobes sub-acute; elaters adhering; spores rather large, oblong and sub-linear-reniform, thickish, red-brown, opaque.

Hab. On branchlets of *Epicarpurus microphyllus* and

Melicope simplex, thickets south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. An interesting and rather curious little species, of pleasing appearance from the large number of its minute and erect flowers peering above its green leaves; its perianths also assume a pale, almost white, colour, making them still more conspicuous with their exserted dark-coloured capsules. It is pretty closely allied to *L. rufescens*, Lind., and also to a British species—*L. minutissima*, Dumort.

3. *L. epiphylla*, sp. nov.

Plant very small, sub ¼in. high, tufted; main stems creeping; branches sub-erect, simple and forked. Leaves close and imbricate, somewhat falcate, oval, dimidiate; tips obtuse, and sub-acute; anterior base produced, margins slightly uneven; lobule broadly ovate, tumid. Perichætial leaves obovate; tips sub-apiculate, obtuse. Cells small, clear, various—orbicular to narrow oblong, walls thick with minute cellules, smaller and more regular at margins. Stipule oval, bifid. Perianth sessile, obovate-oblong, plicate, campanulate when expanded, mouth truncate; tips of lobes rounded, apiculate. Fruit-stalk shortly exserted, curved, transversely ringed; capsule sub-orbicular; valves broadly ovate, split half-way down, pellucid, cellular.

Hab. Epiphytical on *Hymenophyllum* (sps.), woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Genus 23. **Frullania**, Raddi.

§ 2. Lobule vertically elongate, &c.

1. *F. tongariroense*, sp. nov.

Plant prostrate, slender, graceful, 1½in.–2in. long, branched, sub-tri-pinnate; branches alternate, distant, 3–4 lines long; branchlets short, 1 line long. Leaves concave, distant, and large on main stems, less so on branches, close on branchlets but not imbricate, sub-oblate-orbicular or broadly elliptic, dimidiate with anterior margin incurved at tip, apiculate; pale-green with a very narrow purple margin (and so scales); lobule large, purplish-brown, erect, a little inclined from stem, elliptic-clavate, broadest at apex, the tip produced beyond margin of leaf. Scale hippocrepiform, with many fine wavy ciliæ proceeding from the centre; sinus large, spreading, extending half through in depth.

Hab. Among other *Hepaticæ* and mosses on the ground, Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. A species allied to *F. minutissima*, Col. ("Trans. N.Z. Inst.," vol. xix., p. 298). The little dark lobule has a curious

appearance, somewhat resembling a very short-stemmed, small, and plain tobacco-pipe.

2. *F. intermixta*, sp. nov.

A minute prostrate species; stems stoutish, about ¼in. long and $\frac{1}{40}$in. wide, branched; branches 1–2 lines long. Leaves brownish, distant below, sub-imbricate at tips of branchlets, oblate-orbicular, sub-cordate at base, margins slightly uneven; lobule large for plant, dark-coloured, inflated, galeate, upright, tip truncate with a bell-mouth rim produced beyond margin of leaf. Stipules shortly bifid, with two acute teeth on each side. Cells sub-quadrilateral, regular, clear.

Hab. On rotten logs among other and larger *Hepaticæ*, particularly *Gottschea*; low wet woods near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A peculiar little species, having affinity with *F. reptans*, Mitt., *F. fugax*, Hook. f. and Tayl., and *F. pentapleura*, Hook. f. and Tayl., in the shape of its leaves and lobule. Only a few specimens were obtained; probably overlooked from its very minute size and low, creeping, hiding habit. Fruiting specimens not seen.

3. *F. platyphylla*, sp. nov.

Plant rather large (?)—only a single branch seen; 1¼in. long, 1 line wide, bipinnate, dark-brown, flat; branchlets distant, spreading at right angles. Leaves bifarious, much imbricate, orbicular, cordate, clasping, slightly overlapping at base, margins minutely uneven, particularly at base; lobule large, flat, depending, semi-circular-ovate, dimidiate; base free, broad, much arched; tip slender, acute, recurved, slightly produced. Stipule broadly reniform or sub-reniform-cordate, the sinus very small, broad, obtuse, margins slightly uneven, with a small oblong laciniate stipella adpressed at base, and a tuft of small spreading fibres below it. Cells small, orbicular, with very minute interstitial cellules.

Hab. Among mosses, &c., woods, Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. This species strongly resembles *Madotheca stangeri*, Gottsche (itself a variable plant), especially when living (damp) and merely looking at its dorsal side; hence I suppose it to have been overlooked or passed by.

4. *F. diffusa*, sp. nov.

Plant large, dark-green, 2in.–3in. (or more) long, much branched, 3-pinnate, rather rigid, implexed. Leaves on the main stem, distant, reniform, clasping: on the branches, sub-imbricate, broadly ovate, dimidiate, sub-falcate, tips very obtuse and rounded, their cells small, obscure, sub-rhomboidal with black bead-like central points: on the young branchlets,

light-green, oval, margined, their cells sub-orbicular and of various sizes. Lobule (occasional) very small, adpressed to stem, galeate with a short beak, not produced beyond leaf. Stipule small, sub-hippocrepiform, margins entire; sinus slightly oblique, margins uneven, base obtuse; tips coarsely produced, one larger than the other; cells small, obscure. Perianth green, ovate, deeply carinate on one side, densely muricated, shining; tip obtuse, mucronate.

Hab. Forming large spreading overlapping patches on living trees, woods, Dannevirke, County of Waipawa; 1888: *W. C.*

5. *F. cunninghamiana*, sp. nov.

Plant large, greenish, prostrate, creeping, much branched especially at tips of main stems, quadripinnate; branches 1½in.–2in. long. Leaves large, close, imbricate, clasping, sub-vertical, patent, orbicular-reniform, margined; margins slightly uneven, light-brown. Cells small, guttulate. Lobule small, narrow-galeate, adpressed to stem, not produced beyond leaf, tip small, obtuse. Stipules sub-reniform-orbicular; sinus small, margined. Perichætial leaves—the inner erect, much laciniate, flexuous, waved; the outer very broad, sub-orbicular, margins crenate-sinuate; their cells large, oblong-quadrilateral below, guttulate and distinct above. Perianth oblong, trigonous, smooth, one side flat, the other largely carinate; the carina wide, blunt, not extending to mouth; tip truncate, apiculate. Capsule exserted, brown; valves broadly ovate, roughish within; tips sub-acute, abounding in elaters; elaters double-spiral, dilated at ends.

Hab. On living *Podocarpus totara* trees, forming large thick patches; woods, Dannevirke, County of Waipawa; 1888: *W. C.*

6. *F. banksiana*, sp. nov.

Plant small, sub-rigid, scarcely 1in. long, bipinnately branched; branches few, with two stipellæ at base of each branch, and one at each leaf. Leaves distant, oval, margins slightly uneven. Lobule close to stem, narrow galeate; tips long, recurved, partly below margin of leaf. Cells small, sub-orbicular, compact, rather obscure. Stipule broadly oblong; tip sub-acuminate; sinus deep, spreading.

Hab. On ultimate branchlets living trees, woods, Dannevirke, County of Waipawa; 1888: *W. C.*

7. *F. solanderiana*, sp. nov.

(One branch only.) ¾in. long, tripinnate; branchlets numerous, alternate, with long sub-lanceolate-ovate stipellæ at bases of branchlets; pale-brownish. Leaves broadly oval, almost rotund, sub-margined, larger on branch than on

branchlets, pale-brownish. Lobule darker-brown, free, sub-rotund, inflated, patent from stem and projecting below leaf, with a minute acute beak at centre of posterior margin. Cells small, clear, of various shapes, sub-quadrilateral and irregularly angular, walls thick and double with minute cellules in them. Stipules sub-reniform-orbicular, bifid; sinus linear, rather narrow, 2–4 coarse teeth in margins.

Hab. Among *Hepaticæ* (spns.), woods near Dannevirke, County of Waipawa; 1888: *W. C.*

8. *F. curvirostris*, sp. nov.

Plant small; stems stoutish, flattish, 1in. long, nearly 1 line wide, branched; branches alternate, rather long, sub-pellucid. Leaves broadly elliptic, reddish tinged; margins slightly uneven; tips obtuse and sub-acute. Cells clear, orbicular, with very minute interstitial cellules. Lobule large, purplish, galeate, arch much produced, turgid, shining; tip long acuminate, recurved, passing beyond both margin of its own and of the next leaf, slightly sub-imbricate. Stipule large, sub-orbicular, bifid, laciniate.

Hab. Woods near Dannevirke, County of Waipawa; 1888: *W. C.*

9. *F. polyclada*, sp. nov.

Plant forming close matted patches of a few inches each way. Stems 2in.–3in. long, much branched, with numerous very short patent lateral branchlets. Leaves sub-oblong-orbicular or broadly transverse oblong, one end broader than the other, olive-green (young ones and branchlets bright-green), obscure, margined; margins purple and minutely scored or marked with straight transverse lines; lobule small, galeate, tip acute, not extending beyond margin of leaf. Cells indistinct, exceedingly minute and irregular, punctulate, larger clear and broadly oblong in centre at junction with stem. Stipules narrow hippocrepiform, the sinus deep, broad at margin, with the two angles acute. Perianth terminal on short lateral branchlets, green, oblong, tuberculate, keeled sharply on one side, with two smaller carinulæ at the base, the other side flattish; tip retuse and mucronate. Capsule enclosed, globular, large. Involucral leaves large, bifid, acute.

Hab. On indurated clayey boulders, Whangawehi, north side of Table Cape; 1887: *Mr. A. Hamilton.*

Obs. A species very near to *F. echinella*, Col., but differing in its peculiar habit of growth with short starry lateral branchlets—its dimidiate margined leaves with widely different cells—its perianth of a different shape, with straight sides, and more coarsely tuberculate—and its bifid involucral leaves.

10. *F. ichthyostoma*, sp. nov.

Plant 1¼in.–2in. long; branches tripinnate, much implexed. Leaves tranversely set, sub-vertical, orbicular, margins uneven, tips recurved; brown-black, but when young green. Perichætial large, broadly ovate, acute, sub-amplexicaul. Cells various shapes and sizes, oblong, sub-rhomboidal, their edges uneven and curiously sub-crenulate. Stipule small, reniform, with a bunch of rootlets at its base; sinus slightly lateral (resembling a fish's mouth in profile), shallow, spreading, the upper or apical angle larger. Perianth oblong, smooth, sub-4-gonous, largely and bluntly carinate on one side, slightly so and only half-way down on the other; tip mucronate.

Hab. On trees, woods, Dannevirke, County of Waipawa, forming large spreading patches; 1888: *W. C.*

Obs. A species peculiarly marked in the microscopical and regular crenulate divisions of its cells—a curious (if not unique) character; also in the oblique sinus of its stipule—whence its trivial name.

11. *F. pulvinata*, sp. nov.

Stems 1in.–2in. long, much branched and implexed. Leaves orbicular-cordate, margin slightly uneven. Cells oblong with minute interstitial cellules, also (without epidermis) distinct, beaded. Perichætial erect, broadly ovate, acuminate, bifid; lobes acute spreading, sinus deep. Stipule broadly orbicular; margin slightly irregular; sinus rather small; cells guttulate. Perianth flattish, oblong, smooth, slightly keeled on one side, mucronate; mucro stout, obtuse.

Hab. On living trees, woods, Dannevirke, County of Waipawa, forming big patches; 1888: *W. C.*

Genus 27. **Zoopsis**, Hook. f. and Tayl.

1. *Z. basilaris*, sp. nov.

Plant terrestrial, minute, sub-erect, and decumbent, glabrous, pale-green, densely gregarious. Root long (for plant), straight, capillary, hyaline, white with minute spreading lateral rootlets; stem very short, branches simple, and once branched, spreading, 3–4 lines long, $\frac{1}{30}$in. wide, wholly composed of an innumerable number of large transparent orbicular cells, their single narrow walls or divisions (in appearance) intercircling each other, central nerve dark and very stout; the branches linear, 6 cells wide, pretty regularly sub-lobed with alternate gibbous lateral projections, each composed of 2–3 cells with a smaller hemispherical cap, or boss, on the outside one, their tips broader, obtuse. Perianth single, basal, sub-sessile, erect, obovate, $\frac{1}{10}$in. long, composed wholly of cells, no nerves; mouth cut into five rather long acuminate and

acute lobes, tips conniving. A few spreading bifid and trifid cellular scales at its base, with many single narrow linear hyaline spreading fimbriæ below them.

Hab. On the ground among other *Hepaticæ* and mosses shaded wet woods south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species having close affinity with *Z. argentea*, Hook. f., and also with *Z. flagelliforme*, Col. ("Trans. N.Z. Inst.," vol. xviii., p. 250), but differing from the former in habit, in texture, and in colour, in its larger number of lateral cells, and in its not possessing any "ciliiform appendages," or "bristles," or "saw-like teeth" to its marginal bosses; and from the latter in its branches being 6 cells in width, in their not being flagelliferous at tips, in its perianth being basal and much less laciniate, &c. This little plant affords a very pleasing and highly instructive, though tedious, microscopical study.

2. *Z. muscosa*, sp. nov.

Plant prostrate, creeping, forming large thick patches several inches square; light-green. Stems 1in.–1½in. long, $\frac{1}{30}$in. wide, dichotomous; branches spreading largely; nerve stout, dark, flexuous; margins sinuous, regular; cells, very large, subquadrilateral, usually about six in the width of a branch. Long flagellæ, or very narrow sub-rigid branchlets, proceed from main stem and axils at right angles.

Hab. On rotten logs, wet woods near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species near *Z. flagelliforme*, Col. (*supra*), but differing in habit, in its larger size, broader stems and branches with more regular margins, their cells bigger and of a different shape, and the tips of the branches not flagellate.

Genus 30. **Symphyogyna**, Mont. and Nees.

1. *S. platystipa*, sp. nov.

Plant small, stipitate, gregarious, roots shortly creeping, 2–3 fronds together on a rhizome; erect, 1in.–1¼in. high. Stipe slender, pale, sub-rigid, flexuous, flat at top not winged, sometimes once branched near base. Frond broadly reniform, ½in.–¾in. broad, 2-branched; branches short, twice forked; lobes linear, wide, very thin, transparent, bright-green, slightly undulate, margins entire, tips deeply emarginate, nerve scarcely reaching to notch. Cells large orbicular-oblong. Calyptra at base of main forks, three on a plant, sub-peduncled on a small bulbous process, large, broadly reniform, wavy, the ends free not encircling nor adhering; margin entire and slightly sub-sinuate. Within calyptra 12–14 small erect linear pellucid sacs (antheridia), transversely marked in small

squares, their margins minutely constricted at nodes, tips reddish.

Hab. In wet hollows, deep woods south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A species having affinity with *T. flabellata* of Hook., "Musci Exotici," tab. 13 (but not of La Billardiere, "Plant. Nov. Holl.," tab. 254, an Australian species, which I believe to be very distinct).

Genus 31. **Metzgeria**, Raddi.

1. *M. flavo-virens*, sp. nov.

Plant small, gregarious, forming thick sub-erect sub-flabelliform tufts, 3–5 lines diameter; branches irregular, ⅓ line wide, translucent; midrib stout, cellular; margins slightly thickened; yellow-green; crisp when dry. Cells large, hexagonal-orbicular, walls narrow double with minute interstitial cellules. Peduncle usually axillary at forks, sometimes two together, ½ line long, stout, bristly. Involucre small, ovate, acuminate, adpressed. Calyptra oblong-obovate, dark-green, bristly; bristles close, patent, white, pellucid, tips obtuse. Capsule small, globular; cells sub-quadrilateral. Antheridia in alternate scales, ovate, acuminate, laciniate, bristly.

Hab. On trunks of living trees, near their bases, forming dense large spreading patches; dry woods near Dannevirke, County of Waipawa; 1888: *W. C.*

ORDER VIII.—FUNGI.

Tribe III. HYDNEI.

Genus 13. **Hydnum**, Linn.

1. *H. novæ-zealandiæ*, sp. nov.

Large, much and intricately branched from a short thick sub-corky stem; whole mass very compact, surface uneven, roughish, somewhat resembling an advanced cauliflower; branches irregular, flexuous, 2in.–4in. long, pithy, soft yet firm and toughish, whitish below and throughout, with a reddish-brown tinge outside at tips; spines sub-secund, numerous, close but very distinct, of irregular lengths ⅛in.–¼in. long, smooth, subulate, acute, sometimes tips bi- and tri-fid.

Hab. On *Nesodaphne tawa*, forests near Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. Apparently this must form a large plant, as the portion of one brought fresh to me was as big as a small cauliflower, about 4in. across, and evidently severed from a larger part. I may here observe that the species under *H. clathroides* (?), Pall., ("Handbook Fl. N.Z.," p. 611), was also de-

tected by me in these forests just forty years ago; then only once, and never seen by me since. That one, however, was a very different species—as to habit, size of branches and spines, colour, &c. I obtained it in wet weather (when shut up in my tent in these woods by flooded rivers, and no paths), and therefore could not preserve or dry my specimens as I wished.

Art. V.—*A Description of some newly-discovered Phænogamic Plants; being a further Contribution towards the making known the Botany of New Zealand.*

By William Colenso, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 12th November, 1888.*]

Order XXII.—LEGUMINOSÆ.

Genus 1.* **Carmichælia**, Br.

1. *C. corymbosa*, sp. nov.

Shrub erect, 6ft.–8ft. high, much branched, dark-green. Branches terete, long, and slender, sub-erect, spreading and drooping; branchlets sub-semi-terete and flattened, long and flaccid, narrow, 1 line wide (some less), striate on both sides, margins slightly recurved, tips obtuse and sub-acute, generally ending with a scale. Leaves alternate, lateral from notches in edges of branches, with small scarious bracts at the base of the petiole, very few and scattered on lower branchlets (little more plentiful on young plants), membranous, green above, sub-glaucous below, trifoliolate or imparipinnate, ¼in. long, cuneate and cuneate-obcordate, emarginate, the sinus deep with a minute mucro, the terminal leaflet two to three times larger than the lateral pair, which are distant, opposite, and shortly petiolulate, all three jointed; joints pale; veins largely anastomosing, margins entire yet slightly and closely sub-crenulato-denticulate; petioles flat, very slender and narrow, almost filiform, ⅛in.–¼in. long, striate, edges slightly recurved, ciliate at top under limb, with a few scattered weak hairs on petiole and on limb beneath; sometimes there is only the single terminal leaflet, which is then much larger and of the same shape, and sometimes (but more rarely) only the small lateral pair. Flowers scattered, lateral and infra-axillary under younger branches and branchlets, collected in short sub-corymbose heads 8–10 together, 3–4-fascicled, with 3–4 small scarious bracts forming a ring at their base, sometimes

* The numbers attached to the orders and genera in this paper are those of them in the "Handbook, Flora of New Zealand."

(but rarely) in short sub-racemes. Peduncle and pedicels slightly pubescent; pedicels stout, $\frac{1}{10}$in. long, bibracteolate at base of calyx, a bracteole at the middle and another at the base (both peduncle and pedicels lengthen in maturing fruit), bracteoles small, triangular, reddish-brown, and scarious, margins laciniate. Calyx glabrous, cup-shaped, àcutely toothed, edges slightly ciliate. Corolla pale lilac with darker veins, many-nerved; nerves forked at tips; standard oblate-orbicular, $2\frac{1}{2}$ lines across, with a central darker blotch, largely emarginate, unguiculate; wings broadly oblong, 2 lines long, obtuse, auricled; keel broadly oblong-reniform, 2 lines long, tip rounded very obtuse. Anthers sub-rotund; style papillose at top; stigma capitate. Pods single, or 2, 3, 4, or 7 together, elliptic, dimidiate, 3–4 lines long including short beak, glabrous, pale-green when young, grey at maturity, blackish in age, veined; beak stout, subulate, straight, acute, $\frac{1}{20}$in. long (longer and stouter in age); replum very stout and irregularly rugulose close within and around its border, which sometimes extends to its beak; pod internally thinly lined with greyish wool. Seed usually 1, large, $\frac{1}{10}$in. long, reniform, turgid, shining, dark-yellow mottled with purple streaks; sometimes 2 small seeds, irregular in shape and somewhat obtusely triangular, as if the one reniform seed had been divided transversely into two.

Hab. On the banks of streamlets, woods south of Dannevirke, County of Waipawa; 1887–88, flowering in January: *W. C.*

Obs. This, as a species, seems very distinct from all the other known ones; probably its nearest ally is *C. flagelliformis*, Col.

ORDER XXVI.—DROSERACEÆ.

Genus 1. **Drosera**, Linn.

1. *D. minutula*, sp. nov.

A very small stemless species, of close gregarious habit. Roots long (2in.–3in.), straight, vertical, wiry, black, very hairy, 2–3 to a plant. Leaves reddish-brown, rosulate, crowded (8–20) in 2–3 rows, spreading flat on the ground, the whole plant $\frac{1}{2}$in.–$\frac{1}{2}$in. (rarely $\frac{3}{4}$in.) in diameter; leaf with petiole about 3 lines long, the lamina 1 line long, orbicular and sub-orbicular-spathulate, veined, the whole upper surface glandular; margins largely ciliate-fringed, the ciliæ longer than leaf, flat, veined, subulate, wavy, with dark (almost black) knobbed tips, clavate and sub-orbicular and apparently solid, extending round lamina at its base; the glands on centre of leaf sessile, blackish: petioles dark blackish-green, 2 lines long, flat, wide, glabrous, largely winged at bases; wings reddish-brown, membranous, margins entire, acute, and finely

lacerate at tips, with a single acute central lobe adnate on the upper side. Flowers solitary, sometimes two together at top of scape, peduncled. Scape erect, ¼in. high, 1–3 on a plant, one central, others lateral among leaves, with a small subulate bracteole near the top, and at the base of the peduncle of the second flower when 2-flowered. Calyx campanulate, 1 line long, finely papillose and blackish (also scape), lobes 5, cut half-way to base, veined, oblong, very obtuse or sub-truncate, each lobe 5-toothed at tip, sinus broad. Corolla (imperfect) apparently smaller than calyx, and whitish.

Hab. On sides near the top of Mount Tongariro, County of East Taupo, hidden among low herbage and mosses; 1887: *Mr. H. Hill.*

Obs. I. This peculiar little novelty has some affinity with the small New Zealand species *D. pygmæa*, DC. (also found in Australia and Tasmania), but differs from it largely in several characters—as, in its 5-lobed calyx with the lobes obtuse and toothed, its 2-flowered scape, its want of the conspicuously large tuft of silvery stipules at the base of the scape (so very striking a character in that species) and in its still smaller size. It is also allied to *D. uniflora*, Willd., another small rosulate species of Fuegia and the Falklands; from which it also differs in the shape of its calyx-lobes, and in being 2-flowered, and in some other characters.

II. Unfortunately, perfect flowering specimens I have not seen. Indeed, these specimens that I have were only preserved after a great deal of pains and patient labour, for they came to me in little, mouldy, dry, and hard turfs (1in.–2in. long), as cut up out of the black boggy soil in which they grew, and not a single leaf of *Drosera* was distinguishable, and scarcely anything else, those turfs having been also roughly packed, wet, on the spot, and so dried and squeezed in carrying and long-keeping; hence the delicate and small corollas of the *Drosera* (and other plants) were all more or less imperfect. It was only after soaking the turfs in water, and patiently washing and going over them with a stout needle and a camel-hair pencil, that I managed to clean and obtain my specimens. From those turfs, however, I secured more than a dozen plants of the *Drosera*, but not all bearing flowering scapes. Those little lumps also contained several other minute plants, one of them proving to be a *Muhlenbeckia*, sp. nov.,* and the following, which I have also determined: viz., *Claytonia*, sp., *Stackhousia* (?) *minima*, *Haloragis*, sp. (probably *H. minima*, Col.†), *Hypoxis*, *Carex*, sp., some barren mosses, a few very minute *Hepaticæ*, *Cladonia*, (?) sp. nov., with small black

* See p. 98, *infra*.

† "Trans. N.Z. Inst.," vol. xviii., p. 259.

clustered apothecia: all very thickly and almost inextricably growing together, firmly bound down by the very small and twiggy hypogæous *Muhlenbeckia;* and all more or less cut into small bits and broken, with their tender parts decayed.

ORDER XXXIII.—UMBELLIFERÆ.

Genus 1. **Hydrocotyle**, Linn.

1. *H. amœna*, sp. nov.

Plant small, creeping, bright-green, glabrous. Stems hypogæous, 1in.–3in. long, stoutish, flexuous, much branched, rooting at nodes; branches short. Leaves small, scattered singly and in pairs, sometimes three together, orbicular, sub-peltate, 2–4 lines diameter, sinus narrow, 5-ribbed, 5- (rarely 7-) lobed; lobes shallow, tri-crenate, sub-acute, anterior ones imbricate at edges, shining alike on both sides; petioles ¾in.–1¼in. long, stoutish, with a few weak diverging and retrorse flattish hairs at top under leaf. Stipules small, pellucid, bladdery, margins entire. Peduncles same length as petioles, flexuous, opposite to leaves. Umbels usually 6- (sometimes 5-, very rarely 9-) flowered. Involucral leaves 6, oblong, 1-nerved, adpressed; tips obtuse, coloured. Flowers sessile, pale-pink (as, also, styles, the minute calycine teeth, and the central meeting of ribs of leaf); petals deltoid-ovate, sub-acute, spreading. Stamens much exserted, longer than petals; anthers orbicular, didymous, bright-yellow. Styles rather long, curved, diverging. Fruit flattened, glabrous, smooth, ribs indistinct, back obtuse.

Hab. Hidden among low thick herbage, grassy plains, Tahoraiti, south of Dannevirke, County of Waipawa; 1887: *W. C.*

Obs. This little species has affinity with *H. intermixta*, Col. ("Trans. N.Z. Inst," vol. xvii., p. 240), but differs from it in several particulars (*vide descr.*).

2. *H. sibthorpioides*, sp. nov.

Plant procumbent, creeping, straggling, slender; main stems 1ft.–2ft. (or more) long, much branched; branches 6in.–9in. long, red, hairy, rooting at nodes, each node emitting three thick hairy roots. Leaves pale-green, numerous, distant, sub 1in. apart, usually 1 at a node, rarely 2 (and when 3, near tips of branches, then with two umbels of flowers), small, 4 lines diameter (sometimes 3 or 2½, rarely 5), thickish, glabrous, but with long weak coarse succulent hairs thinly scattered on veins upper surface, the lower surface generally free from hairs and very glossy; sub-orbicular-cordate; sinus broad, 7-veined, 6-lobed; lobes cut one-third through, their tips broad, 5–6 lacinio-serrate sub-acute, margins brown; hairs

cellular, patent, white, acuminate, acute, their bases thickened, semi-bulbous. Petioles ½in.–¾in. long, thickly hairy; hairs patent, reflexed. Stipules in pairs, large, obtusely deltoid, finely cut-laciniate, filmy, pellucid, shining, silvery. Flowers opposite to leaf in small globular heads, on short peduncles 1–2 lines long. Umbels 10–20-flowered; flowers small, sessile (but usually 2–3 (at top?) on very short pedicels), crowded, each with a minute oblong-obovate greenish-white 2-nerved bracteole at its base, the nerves very distinct and dark-coloured; petals valvate, broadly ovate sub-acute, pale dashed with red streaks on the outside, minutely pink-dotted within (brown and recurved in age); teeth of epigynous disc dark-red; anthers yellow, oblate-orbicular; styles large, thickish, erect, knobbed, divergent, longer than anthers, persistent. Fruit small, $\frac{1}{16}$in. diameter, slightly oblate-orbicular, broadest at base, flattish, glabrous; at first pale-green without ribs and the dorsal edge very obtuse, but when quite ripe and dry brown, with a fine raised narrow ridge on each mericarp and on dorsal edge; mericarps closely conjoined without any apparent hollow between.

Hab. Shaded woods near Dannevirke, County of Waipawa; 1887; *W. C.*

Obs. This species has near affinity with *H. hirta*, Br., and *H. tasmanica*, Hook. f.; also *H. colorata*, Col. ("Trans. N.Z. Inst.," vol. xviii., p. 260), but is distinct from them all in several important characters. It has been specifically named *sibthorpioides* from its general likeness to *Sibthorpia europæa*, Linn., = Cornish moneywort. It is the plant on which *Orobanche hydrocotylei*, Col., is a parasite. (See paper on that curious plant.)*

Order XXXVIII.—RUBIACEÆ.

Genus 1. **Coprosma**, Forst.

1. *C. pendula*, sp. nov.

Shrub slender, erect, 6ft.–10ft. high, much branched above, trunk bare below; bark thin, smooth, bright reddish-brown, somewhat papery and peeling on trunk; branches very long, implexed and pendulous; branchlets slender, divaricate at right angles, tips of the youngest puberulous. Leaves small, few, opposite, distant 1in.–2in. apart, usually a pair at tips of short lateral branchlets and of branches, orbicular, sometimes broadly elliptic and very obtuse, 3–5 (rarely 6–8) lines long, entire, narrowly margined; margins red, slightly recurved, ciliolate—in age as if slightly muricated (*sub lente*); tips broadly rounded; base sub-truncate, abruptly tapering, sub-membra-

* See above, Art. III., p. 41.

nous-coriaceous, green above, very pale (almost dead-white) below, glabrous, but slightly and finely pubescent at margins; veins obscure and much reticulate on upper surface (compoundly anastomosing, having copious areolæ between them with free veinlets (somewhat like those of some ferns—ex. *Polypodium billardieri*), seen clearly when held up between the eye and light; petioles pubescent and ciliate, 1½–3 lines long, flattish at junction with lamina, sub-trinerved. Stipules short, broadly-ovate, sub-acute, pubescent, the lower connate. Flowers rather large, opposite, supra-axillary, single, and 2–4-fascicled on short, stout, rigid peduncles; pedicels, calyx, and corolla sub-hyaline-membranaceous, very pubescent, pale-greenish with dark-purple stripes and dashes; calyx rather large, half the length of corolla, cup-shaped, 4-lobed, two long and two short lobes, each pair opposite and adpressed, the long pair linear obtuse, the short pair broadly ovate and sub-acute; corolla 1½–2½ lines long, 4-fid cut nearly to base; lobes linear (or linear-oblong), obtuse, recurved: *male* (flower larger than female) — pedicel short, stout, curved; the corolla coarsely and sub-strigosely pubescent, oblong and pendulous before expanding, lobes much revolute in flowering; stamens large, exserted, pendulous; filaments 3 lines long, finely pubescent, white, their bases flattened; anthers 2 lines long, linear-oblong, stout, greenish-white; tips acute, bases sagittate: *fem.*—styles 2, stout, 4 lines long, obtuse, white, densely pubescent: *herm.*—as *m.* and *fem.* (*supra*) conjoined in one flower, the styles a little longer and narrower, sometimes 5–7 lobes to the corolla: and the three kinds of flowers on one branchlet. Drupe small, globular, 2 lines diameter, white, glabrous, shining, semi-pellucid, flesh juicy and sweet; nuts 2, flattish-hemispherical, convex on one side flat on the other, 1 line diameter, white.

Hab. Dry woods south of Dannevirke, County of Waipawa; flowering October, fruiting April, 1887 and 1888: *W. C.*

Obs. I. This is a highly curious species, presenting a very peculiar aspect, both when in foliage only as well as when in flower; differing greatly from all the other species of this genus known to me. Its very long, lithe, pendulous, and strictly divaricate branches—their few small, orbicular, and distant leaves, with their two contrast colours—and its large and exposed flowers—give it a unique appearance; to which may also be added the novelty of its pure-white fruit—rare in this genus.

II. It does not appear to be very common here (where so many other of its congeners abound), and it was some days before I succeeded in finding a single *female* plant—though I subsequently detected 3–4 others. Another shrub was hermaphrodite, or, more strictly speaking, polygamous—the first,

I think, I have ever known of this genus, so pre-eminently diœcious.

2. *C. multiflora*, sp. nov.

Tree erect, 15ft.-18ft. high, much branched throughout and very leafy; bark grey, soft, wrinkled; branches and branchlets very numerous, opposite, not divaricate, sub-erect, spreading; ultimate branchlets thickly pubescent; hairs brown. Leaves small, plentiful, opposite in single pairs, and 2–3 pairs together at tips of branches and short lateral branchlets, the single and the outer pairs always the largest, very membranaceous and soft, sub-orbicular with apices retuse and cuspidate, and broadly-elliptic much acuminate with tips acute, 3–4 (sometimes 5) lines long, their bases gradually tapering into the petioles, glabrous, green on both sides, a little paler on the lower surface with scattered long whitish sub-strigillose weak hairs (young leaves very hairy below), margined and finely crenulate; veins light-red, reticulate, conspicuous on both surfaces; petioles 2–3 lines long, broad and trinerved at junction with limb, very slender at base, densely hairy on under surface; hairs adpressed, sub-strigose; stipules ovate-acuminate, very hairy, their tips glabrous, shining. Flowers: *fem.* very numerous, axillary, mostly sub-fascicled in threes, sometimes single, and 2 together; calyx very small, tube shortly 4-cleft, slightly puberulous (having a double appearance from their close connate stipules, that are larger, with longer acute lobes). Corolla small, 1 line long, green, glabrous, campanulate, 4-lobed, cut scarcely half-down; lobes ovate, acute, recurved. Styles 2, slender, 3 lines long, acute, pink, spreading. Drupe small, globose, 1½–2 lines diameter, slightly depressed at apex, dark-purple, glossy; nuts 2, very small, hemispherical, about 1 line wide; one thick, flat on one side and very gibbous, the other much thinner, scale-like. *Male* flowers not seen.

Hab. Low woods south of Dannevirke, County of Waipawa; flowering November, fruiting April, 1887-88: *W. C.*

Obs. I. This species will naturally rank among the larger ones of this genus. Its striking character when in flower is the prodigious number of its ♀ blossoms, covering the whole surface of the tree from top to bottom, which—from their being coloured and visible from a distance—has a most striking effect. When I first saw it—looking down on it from an open glade in the hill-forest's side—I could not conceive what plant it might possibly be, its whole outside being suffused with a delicate pink hue. It is the only known species of this large and increasing genus bearing such a character. I was much disappointed, however, subsequently, on seeking its fruit (on two occasions—when immature in February, and when ripe),

for I only detected a few, scattered singly here and there on a large leafy branch, many large branches being without any.

II. I sought diligently throughout several days for the *male* plant, but was unsuccessful. Is it likely that the great paucity of its fruit, very unusual in the genus, was owing to the scarcity of male specimens?

3. *C. coffæoides*, sp. nov.

A small tree, slender, erect, 12ft.–15ft. high, perfectly glabrous throughout, bark smooth light-grey; much branched; branchlets erect, scarcely cylindrical, stout, drooping in fruit. Leaves decussate, distant sub-2in. apart on main branches, coriaceo-membranous (membranous and flaccid when young), oblong inclining to obovate-lanceolate, tips sub-acute, slightly mucronate, recurved, tapering to petiole; margins entire, but slightly and closely serrulate (*sub lente*), generally of two sizes —(1) large, on main branches, 3½in.–4½in. long, 2in. broad, petioles ⅛in., stoutish; (2) smaller, on axillary branchlets; darkish-green above, a little glossy, paler and dull below; primary veins diagonal, prominent below; venules obsoletely reticulate. Stipules large, deltoid-acuminate, ¼in. long; tips thickened, hard, acute, black. Flowers: *male*, peduncles axillary, the middle one ⅜in. long; flowers sessile in glomerate heads, 20 and upwards, with several small leaflets interspersed, and narrow oblong bracts at base, their margins minutely ciliolate; calyx a small shallow circular cup, its margin nearly even; corolla pale-green, narrow campanulate, 3 lines long, 4- (sometimes 3-) lobed; lobes one-third length of corolla, ovate, tips sub-acute, recurved; stamens 4 (but only 3 in 3-lobed corolla), slender, exserted, pendulous, flexuous, thickened at top, 3–4 lines long, minutely pilose; anthers narrow oblong, sub-acute, 2 lines long, deeply grooved, largely sagittate: *fem.*, clustered, decussately arranged on short axillary branchlets or peduncles, 1in. long, forming dense, crowded, sub-glomerate heads—20–40 (or more) together; peduncles compressed, with short opposite branchlets or sub-peduncles, each bearing 5–9 sessile flowers, and usually with 1 minute leaf at its base, the main peduncle often continued and produced at top into a leafy branchlet; calyx 0; corolla very small, yellowish-white, $\frac{1}{10}$in. long, somewhat tubular, broadest at top, 4- (sometimes 3-) lobed; lobes very short, obtuse, slightly recurved, their margins dark pink-red, stigmas 2 (rarely 3), short, sub 3-lines long, erect, white, stoutish, obtuse. Drupe glossy, 3–3½ lines long, broadly ovoid, sub-compressed, sides furrowed, tip obtuse, sub-truncate; when quite ripe oblong-ovoid, turgid, juicy, vermilion. Seeds narrow ovoid-acuminate, 3 lines long, slightly curved, somewhat rugulose, dull dirty-white.

Hab. Edges of woods and margins of streamlets south of Dannevirke, County of Waipawa, 1888: *W. C.*

Obs. Flowering in October and fruiting in May. Specimens of the *male* plant have been seen carrying *female* flowers at top of branchlet. As a species this will naturally rank with *C. lucida*, Forst., *C. grandifolia*, Hook. f., and *C. autumnalis*, Col. ("Trans. N.Z. Inst.," vol. xix., p. 263), but is very distinct from them all.

Genus 4. **Asperula**, Linn.

1. *A. aristifera*, sp. nov.

A small, slender, weak, ascending perennial herb; main stems 2in.–3in. long, hypogæous, sub-rigid, wiry, reddish, branched; branches 1in.–2in. high, erect, simple and slightly branched, glabrous. Leaves thickish, glabrous, light-green (as also calyx-tube and branches), 4 in a whorl, $\frac{1}{12}$in. long, sessile, linear-ovate; margins sparsely ciliate; ciliæ usually 4, distant, confined to middle of leaf, stout, white, patent; tips acuminate, bi-, tri-, (sometimes quadri-) aristate, divergent. Flowers terminal in pairs and single in upper axils, peduncled; peduncles longer than leaves, sub-succulent and pellucid, regularly and closely reticulately veined. Calyx-tube glabrous, laterally compressed. Corolla sub-campanulate-rotate, white (sometimes cream-coloured), $1\frac{1}{2}$ lines diameter, 4- (sometimes 5-, rarely 6-) partite, cut nearly to base; lobes linear-ovate, apiculate, sub-papillose, 1-nerved, spreading, recurved; stamens rather long (sometimes 5); anthers bright-yellow. Styles united below, tips free, rather long, spreading; stigmas globose.

Hab. Open grassy plains, Tahoraiti, south of Dannevirke, County of Waipawa; 1887, flowering in November: *W. C.*

Obs. A highly curious little species, apparently near to *A. perpusilla*, Hook. f., but differing largely in several particulars. Having seen some hundreds of living plants, I find their characters (*supra*) constant. Its little white star-like flowers make it to be conspicuous among the low grass and other small herbage. It seems (to me) to be nearly as much allied to *Galium* as to *Asperula*; and under *Galium* I should prefer to place it but for its close natural ally, *Asperula perpusilla*.

Order XXXIX.—COMPOSITÆ.

Genus 3. **Celmisia**, Cass.

1. *C. setacea*, sp. nov.

A small slender species, slightly cottony; apparently growing singly. Leaves few (6–8), 2in.–3in. long, $\frac{1}{2}$ line wide, sub-setaceous, greenish-grey, flaccid, drooping, margins revolute, tips acute; their bases dilated and sub-sheathing,

glabrous and reddish on the outside, very loosely cottony within, mid-rib on under surface glabrous (and also the whole upper surface in age). Scape single, very slender, 7in.–8in. long; bracts setaceous, 3–4 lines long, very acute, rather distant (6–7 on scape), and closely appressed. Head small, loose, spreading, ½in.–¾in. diameter. Involucral scales few, somewhat disposed in 3 rows (of same length as disc-florets and pappus), 5 lines long, the outer ones the shortest, linear-acuminate with 1 dark central vein, slightly cottony on the outside, tips very acute, margins finely serrulate and ciliate with weak shaggy hairs. Ray-florets 14, distant, sub-lanceolate, 5½ lines long, 4-veined, extending far beyond stigmata; tips obtuse, 1-notched; tube 2 lines long, about one-third length of floret. Disc-florets few, 8–10; stigmas long, subulate, curved, very tuberculate; tubercles linear, obtuse. Pappus pale-reddish, short, nearly equal in length, about as long as tube of ray-florets, scabrid; tips acute and bifid. Achene linear, 1½ lines long, angled somewhat 4-sided, glabrous.

Hab. On open ground, high slopes of Mount Tongariro, County of East Taupo; 1887: *Mr. H. Hill.*

Obs. This slender species is more nearly allied to *C. longifolia*, Cass. (a common New Zealand, Australian, and Tasmanian plant), but differs from that species in many particulars—as, in its single habit of growth, its shorter filiform leaves, more slender scapes with shorter setaceous cauline bracts, much smaller head and fewer ray-florets, shorter and glabrous achenes with pappus-bristles nearly equal. Bentham says of *C. longifolia*: "Ray-florets above 30; achenes fully 3 lines long, more or less silky-pubescent. Pappus-bristles very unequal, the shortest half as long as the longest." ("Fl. Australiensis," vol. iii., p. 489.) I quote from Bentham (who also notices our New Zealand plant from Hooker f.) as being the latest work, with a fuller specific description.

Genus 17. **Senecio**, Linn.

1. *S. pumiceus*, sp. nov.

Plant a sub-erect glabrous perennial herb, 2ft.–3ft. high; stems striate, stout below, ½in. diameter, much branched above, slender and sub-flexuous; flowering stems 8in.–10in. long; striæ broad, flattish, yellow-brown. Leaves light-green, purple on under surface, sessile, half-clasping: *the lower ones on main stems* close, oblong, 4½in. long, 1½in.–2in. broad, sub-membranaceo-coriaceous, somewhat wrinkled, veins anastomosing, prominent below also the mid-rib; margins grossly serrate and slightly revolute; tip acute; base cordate: *the upper leaves on flowering stems* linear-oblong (sometimes lanceolate), 2in.–3in. long, ½in.–1in. wide, sparingly toothed

(teeth very small) and entire, sometimes but rarely sharply serrate, their bases produced much beyond the stem on the opposite side, membranaceous, decreasing in size upwards, distant; veins largely anastomosing. Flower-heads not large, 3–4 lines diameter, disposed in spreading loose corymbose panicles; peduncles 2in.–4in. long, much and dichotomously branched above; pedicels ½in.–1in. long, very slender, with scattered small bracteoles throughout. Involucre small, campanulate, 1½ lines long (4 lines diameter when spread out flat), glabrous, glistening, slightly rugulose and scabrid at base; lobes 13, oblong-ovate, about 1 line wide, suddenly subacuminate, their centres thick, 2–3 dark-green stripes, 1–2-nerved, nerves yellow; margins membranous, pellucid, very broad, much imbricated, finely and regularly lacerate; tips pilose (semi-tufted), hairs white; several (5–8) small subulate spreading bracteoles with pilose tips close to base. Flowers bright orange-yellow, glabrous, all florets much dilated at bases of tubes. Receptacle white, flattish, alveolate, the alveoles large, sub-quadrilateral, with high-toothed borders, and punctulate in centre, edges of punctures raised. Ray-florets 10, ligulate, 3½ lines long, much recurved; ligule oval, largely veined; veins about 8, the main ones forked at apex; tip retuse, with two small notches, extending far beyond stigmata; the tube short, one-third length of floret, its style glabrous, recurved, tips not dilated, and when spread out not so wide as ligule. Disc-florets very numerous, 40 and upwards, tubular, 2½ lines long (about two-thirds length of ligulate florets), narrow campanulate or sub-infundibuliform at mouth; anthers included; lobes veined; tips erect, subacute. Pappus erect, 2 lines long, fine, white, scabrid; tips acute. Achene linear, $\frac{1}{10}$in. long, sub-4-sided, deeply sulcated on two opposite sides, pale-brown, glabrous, but minutely hairy in lines on the angles; hairs short, white, distant.

Hab. "Face of pumice rocky boulders near the sea, Whangawehi" (cliffs, north side of Table Cape, East Coast); January, 1888: *Mr. A. Hamilton.*

Obs. I. This plant is certainly allied to *S. banksii*, Hook. f.,* also to *S. velleioides*, A. Cunn. (an Australian species); but, after much examination and study, I believe it to be specifically distinct from both. Having received plenty of good specimens from its discoverer, Mr. Hamilton, and being very desirous of clearly ascertaining the true position of this fine plant, I have very closely and exhaustively examined it, as will, I presume, be allowed from the description given

* "*S. odoratus*, Hornemann," of "Handbook N.Z. Flora;" but subsequently corrected by Hooker himself, in his "Additions, Corrections," &c., at p. 784, *l.c.*, and the name of *S. banksii* restored.

above. It differs from *S. banksii* (*vera*) in several characters: that plant has "linear-oblong leaves, slender blunt involucral scales, very short ligulæ" (ray-florets), and "long achenia." ("Flora N.Z.," vol. i., p. 147.) It also differs from the allied Australian species, *S. velleioides*, in the much shorter bracts and shorter disc-florets (and probably very much broader ray-florets) of this plant. Bentham, in his description of *S. velleioides*, says, "Involucral bracts 3–4 lines long, with a very few small outer ones; disc-florets scarcely exceeding involucre." ("Flora Austral.," vol. iii., p. 668.)

II. Hooker, under *S. banksii* (*l.c.*), has also given, with a doubt, two New Zealand varieties of that species: one of them, "var. *β velleia*," may prove to be identical with this plant. Unfortunately, Hooker says but very little about its differential characters, but that little is more in agreement with this plant. I quote his remarks: "Var. *β* (?) *velleia*; robustior, foliis rigide coriaceis subtus glaucis venis prominulis, capitulis latioribus, acheniis brevioribus." And, again: "The vars. *β* and *γ* may belong to different species, but my specimens of them are very indifferent. Var. *β* is a very thickly leathery-leaved plant, with stout stem and branches of the corymb, which bears very numerous broader heads, that have much shorter achenia."

I may further observe that Hooker also gives the *hab.* and discoverers of *S. banksii* and its two varieties thus: "*Hab.* North Island, East Coast; *Banks* and *Solander, Colenso.*" And the facts pertaining to the same, taken in connection with the discovery of this plant by Mr. Hamilton on the north side of Table Cape, seem to point to something more than a casual coincidence: for Banks and Solander were only on shore on the east coast at Poverty Bay and Tolaga Bay, a few miles north of Table Cape; and my specimens were also detected by me in nearly that same locality—viz., between Tolaga and Poverty Bays—in travelling along the east coast early in December, 1841. I have never visited Table Cape.

[Since writing the above I have referred to some brief notes of that journey, written by me at the time to Sir W. J. Hooker (to accompany my specimens), and shortly after published by him in the "London Journal of Botany," vol. iii., p. 16: from them I make the following extract:—

"Dec. 9th, 1841.—I was fortunate enough to obtain here on the clayey cliffs three species of *Compositæ* quite new to me. One (No. 25) grew commonly about the bases and faces of the low clayey and sandy cliffs, and often attained the height of 4ft.–5ft. Another (No. 46) was found in similar situations, and of the same height as the preceding: the peculiar glaucous leaves of this last, so much resembling those found on the flowering

stems of many varieties of *Brassica oleracea*, greatly attracted my notice."

This locality was on the immediate sea-coast between Pakarae and Poverty Bay, and near to Whangawehi, Table Cape; and I have scarcely any doubt of the said specimen (No. 46) being identical with the plant here described. The season, too, accounts for my specimens (and still more so for those of Banks and Solander, who were a month earlier on the coast) being imperfect—*i.e.*, not fully developed.]

ORDER XLII.—ERICEÆ.

Genus 2. **Pernettya**, Gaud.

1. *P. macrostigma*, sp. nov.

A small prostrate shrubby plant. Stems woody, much branched; branchlets short, 1in.–2in. long, irregular, glabrous, with a few scattered long weak flexuous hairs, the very young branchlets and leaves finely pilose. Leaves scattered, linear-lanceolate, 3 lines long, ½ line wide, green, glabrous, patent; tips obtuse, coloured; margins distantly and regularly serrulate, usually 3–4 teeth; teeth white, sub-pellucid, each with a dark hair-like point; petioles short. Flowers small, single, axillary, peduncled; peduncle short, curved, glabrous, with 3–4 broadly ovate bracts at base. Calyx-lobes cut nearly to base, ovate, sub-acute, purple and green, finely pilose within; margins ciliate. Corolla $\frac{1}{10}$in. long, globose-campanulate, white, veined; lobes short, blunt, tips much recurved. Stamens ovate-acuminate, 1-veined, muricated throughout; tips plain, obtuse, slightly recurved. Style longer than corolla, erect, stoutish, glabrous; stigma large, jagged, spreading; ovary prominently 5-lobed, pilose. Fruit globular, 2 lines diameter, pink.

Hab. Open grounds on dry hills in the interior, Glenross Station, County of Hawke's Bay; December, 1887: *Mr. D. P. Balfour.*

Obs. A species near to *P. tasmanica*, Hook. f., which it also resembles in general appearance. Unfortunately I have had but two small specimens, containing only a few flowers, to examine. One very peculiar character it possesses is that of the calyx, pilose within.

Genus 8. **Dracophyllum**, Lab.

1. *D. recurvatum*, sp. nov.

An erect and tall shrub, or small slender tree, "25ft.–30ft. high," branched at top; trunk below bare, 3in.–4in. diameter; bark smooth, greyish. Branches sub-erect and compound; branchlets bare, cylindrical, 4 lines diameter; bark smooth, pale red-brown, pretty regularly annulated with rings of fallen

leaves, the rings 1–2 lines apart. Leaves terminal in bunches at tips of branchlets, sub 20, close, imbricate, amplexicaul, linear acuminate, 16in. long, ¾in. wide at base, sub-coriaceous, smooth, glossy, finely striate, light-green, their upper half exceedingly narrow, tips subulate acuminate, flexuous; their bases orange-coloured, thin, dilated; margins entire (to the eye), but under a powerful lens minutely and distantly bluntly denticulate. Flowers terminal, numerous, crowded, paniculate in a narrow thyrsoid-panicle, 5in. long, 1½in. wide, linear-lanceolate, erect, red, sometimes 2 panicles together; peduncle very stout, 2in. long, ringed, puberulous; panicle and pedicels pubescent; sub-panicles 1½in. long, mostly 4-branched; branches 6–8 lines long, each bearing 9–14 flowers; pedicels short, 1 line long. Sepals sub-oblate-orbicular, veined longitudinally; tips broad, angular; much and finely laciniate; laciniæ acute. Corolla sub-campanulate, 2 lines diameter; tube short, lobes longer than tube, oblong-ovate, wavy, recurved, appressed, 1-nerved; tips obtuse and slightly denticulate. Stamens long, exserted, largely decurved. Anthers large, oblong-ovate, cordate; tips very obtuse, versatile and pendulous appressed around corolla. Style stout, exserted; stigma sub-clavate, capitate, puberulous. Hypogenous scales broadly oblong; tips sub-truncate, denticulate. Capsule (mature and old) very small, orbicular, about 1 line diameter, depressed, reddish.

Hab. On high grounds, "from 2,000ft. to 3,000ft. alt.," hills around Lake Waikare, County of Wairoa; 1888: *Mr. H. Hill.* Also, seen there earlier by Mr. A. Hamilton.

Obs. This is a very fine species of *Dracophyllum*, the largest known of our New Zealand species. I had casually heard of it some time ago, but only from settlers, who called it "neinei," the Maori name of the large northern species *D. latifolium;* and therefore, as well as from their very imperfect account of the plant, I had supposed it to be identical with that species: but it is widely different in almost every principal character; its largely-recurved corolla-lobes and anthers, being peculiar and abnormal, give it a singular appearance. It seems, however, to be of various stature: Mr. Hill (who kindly brought me the specimens I have described, gathered by himself) saw it growing singly and sparingly in open and lower grounds, where it was only "from 6ft. to 10ft. high," and the diameter of its bare trunk "about 3in.," its branches assuming a sub-pyramidal form, the largest and lowest being "about 6ft. from the ground." Mr. Hamilton, however, had seen the plant at a much higher altitude on the same range, forming "extensive thickets or groves," and "from 25ft. to 30ft. high," with their bare trunks below "4in. diameter."

Order XLIII.—MYRSINEÆ.

Genus 1. **Myrsine**, Linn.

1. *M. pendula*, sp. nov.

A small slender tree, erect, 10ft. high, trunk below for 4ft.–5ft. bare; branches many, long, pendulous; young branchlets finely and thickly pubescent, straight or slightly curved; bark reddish-brown. Leaves numerous, alternate, close and scattered, single and in pairs, orbicular and oblate-orbicular, retuse (sometimes sub-emarginate and sometimes rounded), usually 3–4 (rarely 5–6) lines diameter, not tapering to petiole, patent, green above pale below, sub-membranaceous, dotted with a few scattered dark-orange globular raised dots, and with several smaller and linear-oblong ones; veined, veins spreading, sub-flabelliform; veinlets finely reticulated; margin slightly uneven, thickened, closely lined with dark-orange raised globular dots (making the edge to appear as if it were coloured red); ciliated, ciliæ flattish, short, ragged, irregular, weak; petiole very short, pubescent, with small thickish dark-coloured stipellæ at base. Flowers axillary, scattered, single, sometimes in pairs (rarely 3 together), very minute, 1 line diameter; peduncle very short. Calyx pale-greenish, glabrous, 4-lobed, not cut to base; lobes broadly ovate, obtuse, ciliolate. Corolla, petals 4, brown, oblong, obtuse, recurved from middle and appressed, 1-nerved, much reticulated, with a few (4) minute scattered glandular dark-orange dots; margins ciliate and fimbriate; fimbriæ crisp, crinkled. Anthers 4, dark-brown, deltoid-ovate, sub-cordate, appressed, tips minutely crested, crinkled; filaments very short beneath ovary half the length of the anther. Stigma sessile, large, depressed, irregular, spreading. Ovary ovoid-orbicular. Fruit large, globular, 2½ lines diameter, purple, glabrous; apex depressed, hollowish.

Hab. Woods near River Mangateraa, south of Dannevirke, County of Waipawa; 1888: *W. C.* Flowering in October and fruiting in May.

Obs. A species very near to *M. divaricata*, A. Cunn.; but differing from it in its larger size and habit, in form position &c. of its leaves, in its fimbriated petals and its peculiar crested anthers, and in its larger depressed and purple fruit. When closely examined and compared with the very full and able description and drawing with numerous dissections of *M.* (*Suttonia*) *divaricata* given by Hooker f. in his "Flora Antarctica," vol. i., p. 51, tab. 54, this species will be found to differ considerably in many particulars. In drying the specimens their leaves fall off in large numbers; they also become sub-rugulose and shrivelled on the lower surface.

ORDER LI.—CONVOLVULACEÆ.

Genus 1. **Convolvulus**, Linn.

1. *C.* (*Calystegia*) *truncatella*, sp. nov.

Perennial, very large, diffuse, spreading, largely branched, twining and climbing over bushes and shrubs (almost smothering them), and up trees 8ft.–10ft. or more. Leaves membranaceous, distant, undulate, sub-orbicular-cordate, 1¼in.–1½in. diameter, dark-green, 5- (7–9-) nerved; nerves (and veins) reddish, sub-translucent; basal lobes large, wide, rounded; sinus very broad and deep and truncate at base (2 lines wide at top of petiole); tips obtuse and retuse, with a small abrupt mucro; margins sub-sinuate, much slightly angularly-toothed; largely veined, veins anastomosing; petioles 1in.–2in. long, semi-terete, channelled above, spotted light-purple and green, minutely pilose. Flowers scattered, solitary, axillary; peduncles 4in.–5in. long, 4-angled, spotted like petioles, glabrous; bracts large, generally 3, sometimes alternate, orbicular-cordate, tip retuse, mucronulate, largely veined, veins anastomosing, margin red, sinuate and sub-angulate; the outer pair 4–5 lines diameter, longer than calyx and distant from it, the inner one close to calyx. Calyx-lobes 4–5, broadly elliptic, mucronate, closely longitudinally veined. Corolla pure-white, broadly campanulate, spreading, 1¼in. long, 1¾in. diameter, much veined longitudinally; lobes broad and angular, tips obtuse, margins slightly and irregularly sub-denticulate. Stamens slender, very sparingly muriculate at base. Anthers large, oblong-ovate, tip very obtuse, base auriculate. Style exserted much longer than anthers. Stigmas large, broadly oblong-clavate or sub-reniform, dimidiate, gibbous, pedicelled, diverging. Capsule large, glabrous, glossy, dark olive-green, sub-quadrately-rotund, 5 lines long, 4–5 lines diameter, turgid with 4 longitudinal depressions, tip sub-acute with a stout straight beak 1 line long. Seeds 4, large, dark orange-red, smooth, ⅛in. long, sub-reniform-ovoid, 3-sided, flattened and sub-rugulose on two sides, very turgid on the third; testa very hard.

Hab. Banks of streamlets and edges of woods, Seventy-mile Bush, south of Dannevirke, County of Waipawa; 1887–88: *W. C.*

Obs. I. This plant is nearly allied to *C. tuguriorum*, Forst., but differs from that species in several characters, the more striking being its much larger size and spreading climbing habit, its differently-shaped leaves with their remarkable truncated bases and broad basal lobes, its double row of large calycine bracts, round-topped sepals, obtuse anthers, large globular capsule, and big red seeds. The leaves on its young

and ultimate branchlets are much smaller and closer; perhaps in age they increase in size and distance. I have a specimen bearing 2 flowers on 1 peduncle.

II. This species flowers profusely in February, when it presents a very pleasing appearance from the pure-white of its large, exposed, and numerous flowers. It has potent and active enemies among some of the smaller-winged insects, which eat away the thick stigmas, and lay their egg at a very early date within the immature ovarium, piercing it with a minute hole for that purpose, which, however, does not affect the growth of the capsule or its seeds. In due time a small larva issues from the egg, that devours the seeds. This caterpillar invariably attacks the seeds in the one soft part at their base (*hilum*), the testa being very hard, and is sometimes to be found snugly ensconced within the seed; the seeds when "cleaned out" still retaining their position, size, and colour. I have never found more than one hole in a capsule, and only one larva inside. Such is the havoc occasioned by this minute insect, that it is a very difficult matter to find a whole capsule containing perfect seeds. I have gathered scores (perhaps hundreds) of good-looking capsules, both ripe and unripe—such, too, as were fine and healthy-looking on the plants—but only, in nineteen cases out of twenty, to find them useless—without a sound seed; tenanted if new, or the insect perfected and fled. It must be a very tiny creature, as it emerges by the original small hole without destroying the capsule.

III. A judicious remark of Forster's on this genus may be mentioned here: "The species of *Convolvuli* are very copious in the South Sea isles, and so closely connected with each other that it becomes very difficult to determine them." ("Observations," p. 181.)

Order LIII.—SCROPHULARINEÆ.

Genus 6. **Limosella**, Linn.

1. *L. ciliata*, sp. nov.

Plant small, tufted, creeping by surculi, glabrous, rather pale-green, perennial. Leaves erect, spreading and drooping, sub-terete, succulent, minutely dotted, connate in young plants, 8–10 lines long, linear filiform; tips obtuse, rarely very slightly dilated; half-clasping at bases. Flowers single, axillary at bases of leaves, several on a plant; peduncle short, stout, thickened in a ring at top below junction with calyx. Calyx sub-campanulate, 5-partite, segments sub-acute, each marked with a dark-red longitudinal line at base on calyx-tube. Corolla white (sometimes tinged with blue streaks on the outside), campanulate-rotate, 5- (sometimes 4- and 6-)

lobed, 1¼ lines diameter, nearly twice as large as calyx; lobes large, oblong, obtuse, hairy within and ciliate on the lower half of margins. Stamens exserted; anthers orbicular, bluish. Style long; stigma large, orbicular, much papillose. Capsule sub-globose.

Hab. On mud-flats, margins of streams, Hawke's Bay, forming large patches; 1846–52: *W. C.* 1888: *Mr. A. Hamilton.*

Obs. A species pretty near to *L. aquatica*, Linn. (and its varieties), but differing in several particulars: as, in its smaller size; its linear filiform semi-terete leaves, which are truly connate in young plants; its larger flowers, the corolla being twice as large as the calyx, with obtuse hairy and ciliate lobes, long style, and large globular stigma.

Genus 7. **Veronica**, Linn.

1. *V. parkinsoniana*, sp. nov.

A tall slender erect shrub, 9ft.–12ft. high, with long slightly-drooping branches, that are bare below and sparingly leafy at tops. Leaves rather distant, lanceolate, 4in.–5in. long, ¾in. broad, glabrous, smooth, sessile, midrib prominent and keeled below towards base; margins entire; tip obtuse. Flowers axillary, racemed; racemes slender, 6in.–7in. long, pubescent—as also pedicels, bracteoles, and calyces; pedicels 2 lines long, slender, curved; bracteole at base long, half the length of pedicel, linear, acuminate, 1-nerved. Calyx small, about 1 line long, lobes not cut to base, narrow ovate-acuminate, 1-nerved, finely ciliate. Corolla white, with pale-lilac tinge, ⅓in. diameter, sometimes 5-lobed, and then the middle lower lobe is the smallest; tube longer than lobes, 2 lines long. Stamens long, much exserted, longer than corolla, broad, compressed, curved, spreading. Style persistent, slender, very long, more than twice the length of capsule, much curved, pubescent. Capsule twice the length of calyx, broadly ovoid, laterally compressed, glabrous but finely puberulous at tip.

Hab. Edges of thickets, country south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. A fine species, near to *V. salicifolia*, Forst., but differing largely in capsule, calyx, &c.

Genus 9. **Ourisia.**

1. *O. calycina*, sp. nov.

Plant erect, stout, glabrous. Leaves broadly ovate, (?) 4in.–5in. long, dark-green, largely crenate. Petioles nearly as long as lamina. Scape 11in. long (not fully extended), stout, angled, deeply sulcated below, with a line of weak

hairs on each prominent angle (this hairy line is decurrent from the outer angle of base of each cauline bract, 8 lines in all). Bracts on scape: the two lower pairs diphyllous, opposite, sub-sessile, thickish, much and reticulately veined; the lowest pair narrow oblong, 2in. long, 7 lines wide, sides straight, deeply crenate, acute, without flowers; the next pair smaller, with 3 flowers: the upper bracts in whorls (6 in number), all quadriphyllous, sessile, oblong-lanceolate, 1in. long (the uppermost $\frac{3}{4}$in.), 3-nerved; tip obtuse knobbed; margins serrate, purple, their lower half thickly ciliate; ciliæ flat, wavy; each whorl bearing four flowers; all the whorls nearly equidistant, about $1\frac{1}{2}$in. apart. Pedicels—the lower 3in., the upper $1\frac{1}{2}$in. long, angled, stout and rigid below at bases, slender filiform and drooping at tips, each with a single line of weak hairs. Calyx glabrous, 5 lines long, very rugose and wrinkled at base, 5-partite, lobes oblong, sparsely ciliate at their bases, 3-nerved below, only the central nerve percurrent, much reticulated between the outer veins and margins, the inner interstices clear; margins 2-denticulate, teeth obtuse and, with the tip, knobbed and coloured. Corolla pure-white, 1in. diameter, largely and dichotomously veined, the two upper lobes much shorter, broader, and rounder at tips; tube short, sub $1\frac{1}{2}$ lines long, half the length of tube, stout, broad; throat densely lined with lemon-coloured, jointed, and sub-acute hairs. Anthers large, sub-orbicular-reniform. Fruit sub-orbicular, turgid, sub 2 lines long, scarcely half as long as calyx-lobes which enclose it, with a beak and very long persistent flexuous style.

Hab. Highlands on River Waimakariri, near Bealey, South Island; 1888.

Obs. I have only seen one specimen of this plant, but in a good flowering state and fresh; gathered there by a visitor and sent to Napier; its lower stem was wanting, and basal leaves imperfect.

Order LXIII.—POLYGONEÆ.

Genus 2. **Muhlenbeckia,** Meisn.

1. *M. hypogæa,* sp. nov.

A small prostrate twiggy shrub, extending a few inches (?) each way; much branched; main stems and branches being underneath the soil, and rooting at nodes, 4in.–5in. long, flexuous and very slender, $\frac{1}{2}$ line diameter, with only the tips of the smaller ultimate branchlets appearing above, and then also prostrate and closely appressed; bark dark red-brown, epidermis thin sub-bladdery; branchlets numerous, very short and intermixed, the younger ones striate and minutely papillose. Leaves few, scattered, orbicular, $\frac{1}{10}$in.–$\frac{1}{12}$in. wide (fre-

quently smaller), thickish, margins entire; mid-rib prominent on under surface, veins obscure, petiolate; petioles stoutish, half length of leaf, channelled above. Bracts (*ochreæ*) entire, bladdery, pale red-brown, very numerous. Perianth solitary, sessile or sub-sessile, rugulose, a little shorter than fruit, closely adpressed, fleshy (in some specimens), 5-lobed, lobes cut half-way to base, oblong, sub-acute; nut 1¼ lines long, rhomboidal, triquetrous, angles obtuse, sides concave, tip acute, black, smooth not shining.

Hab. On the sides and near the summit of Mount Tongariro, county of East Taupo, almost entirely hidden among low small herbs and mosses; 1887: *Mr. H. Hill.*

Obs. A very minute, peculiar, and distinct species, of which, unfortunately, I have only a few specimens, found by me concealed in little turfy lumps of dark boggy earth, brought from the mountain by Mr. Hill.* The leaves and fruit had mostly fallen off from their branches through damp and close packing, but the bracts remained, and all were perfect, though I only obtained about half a dozen nuts and perianths, and have not seen any floral organs.

2. *M. paucifolia*, sp. nov.

A low prostrate rambling shrub, extending 5ft.–6ft. Branches stout, bark glabrous, longitudinally wrinkled and channelled, dark red-brown. Leaves few, scattered, light-green, broadly elliptic and sub-rotund, 3–6 lines long, obtuse, sometimes retuse, glabrous, rarely contracted at middle, sub-membranaceous, veins anastomosing obscure (visible when dried); petioles half as long as leaves, slender, channelled above, finely and closely tuberculate; stipules ovate, acute. Flowers in terminal racemes at tips of short lateral branchlets; racemes simple, short, about ½in. long, finely pilose, each bearing 5–7 (rarely 9) flowers, alternate and rather distant; bracts (*ochreæ*) rather large, open, glabrous, pale reddish-brown, obliquely truncate, acuminate with one long stout sub-aristate nerve; margins entire or finely and shortly ciliate (*sub lente*), each bearing a single flower; pedicels longer than bracts. Perianth (and pedicel) white, lobes cut half-way to base, oblong, obtuse, conniving; stamens longer than lobes; anthers sub-orbicular, didymous, sub-versatile, white. Stigmas small, red, glabrous, acute. Ovary (immature) pink, slightly tuberculate.

Hab. On mounds of indurated pumice, &c., at Whangawehi, north side of Table Cape; December, 1887: *Mr. A. Hamilton.*

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* See "Observation" under "*Drosera minutula*" (*suprà*), p. 82, for a more particular description of these little turfy specimens.

Obs. This species of *Muhlenbeckia* presents a peculiar appearance, from its stout almost gnarled branches, few pale-green leaves, and numerous short lateral branchlets tipped with flowers, whose pedicels are also white. It is allied to *M. complexa*, Meisn., and to *M. microphylla*, Col., but is widely different from both.

3. *M. trilobata*, sp. nov.

Plant decumbent, much branched and implexed, rising twining and climbing over low shrubs and herbage. Branches long, striate, densely pubescent; hairs short, patent, red-brown. *Fem.*: leaves alternate, distant, membranaceous, glabrous, green, 1in.–2in. apart, broadly ovate (in outline), ¾in.–1½in. long, ¾in.–1in. wide, wavy, sub-panduriform, deeply trilobed, largely cordate; lobes much rounded, apical lobe large, sub-sagittate; tip suddenly acute and sub-apiculate; sinuses broad; margins red, sub-entire, irregular; midrib prominent on the under surface, pubescent on the upper; veined; veins very closely and compoundly reticulate, having copious areolæ between them with free veinlets, but somewhat obsolete when fresh. Petioles ½in.–¾in., sub-terete, channelled above, soft, pubescent; cauline stipules (*ochreæ*) large, truncate, nerved, pubescent on nerves. Flowers irregularly disposed, usually in axillary racemes 2 together; racemes rather slender, nodding, 2in.–2½in. long (sometimes panicled with 3 basal branches from 1 peduncle, and sometimes in a large loose panicle 5in.–6in. long, distantly and gracefully branched in 8–12 racemes), vaginant; vagina rather large, very membranous, sub-pellucid, cup-shaped, margin laciniate; the flowers sub-fascicled 2–4 from each vagina, largely exserted, close-set but not crowded; pedicels jointed, capillary, 2 lines long. Perianths pale-green (sometimes, but rarely, with bright-red bases), 2 lines diameter, membranous, free from ovary, glabrous; lobes shorter than nut, broadly spathulate, not cut to base; sinuses broad; tips rounded. Stigmas 3, sub-clavate-orbicular, papillose, spreading; anthers very minute, abortive. Nut black, shining, broadly elliptic, 2 lines long, triquetrous, one side broader and flat, free from perianth. *Male* (also, sometimes, hermaphrodite): leaves much smaller. Racemes axillary and terminal, slender, simple, 1in.–2in. long; floral bracts distant; 4–5 flowers in 1 sheath; perianth membranous, greenish-white, sub-campanulate; tube longer than lobes, free; stamens longer than perianth (and nut), flexuous, spreading; anthers exserted, orbicular, emarginate and cordate, didymous, red. Nut sometimes as in female.

Hab. In woods south of Dannevirke, County of Waipawa; 1888: *W. C.*

Obs. This is a pleasing, handsome, and striking species,

from the extreme gracefulness of its slender pendulous open racemes, and the regular shape of its peculiarly-formed leaves. Sometimes the leaves of other and allied species assume a contraction in the middle, giving them a kind of sub-panduriform shape, but none are so deeply and so regularly lobed as these. This character pertains alike to both *male* and *female* plants, although the leaves of the male plant are very much smaller than those of the female.

4. *M. truncata*, sp. nov.

A slender rambling climbing twining shrub, rising to 8ft.–9ft. among shrubs and trees. Branches very long and slender, flexuous, closely twining, thickly pubescent; hairs very short, red. *Fem.:* leaves membranous, numerous, scattered, sometimes fascicled in pairs, broadly oblong, ½in.–¾in. long, sides straight, tip obtuse rounded rarely apiculate, base truncate; dull pale-green, glabrous, wavy, opaque; margins entire, red; veined, veins slightly anastomosing. Petiole very slender, almost capillary, 4–5 lines long, puberulous. Cauline bracts long, truncate, margins entire. Flowers disposed in simple short racemes ½in.–1in. long, and 5–12-flowered; raceme vaginant; sheaths small, reddish, funnel-shaped, oblique, with 1 long stout excurrent nerve; margins finely serrate. Pedicel short, scarcely longer than sheath, with a single narrow line of pubescence. Perianth small, shorter than nut, whitish or very pale-green, very membranous, free; lobes oblong, obtuse, appressed and spreading, not cut to base, 1-nerved; veins finely reticulated (*sub lente*). Nut very small, about 1 line long, sub-rhomboidal or broadly lanceolate, trigonous, sides equal, angles obtuse, ridges irregular, brownish-black, dull not glossy. Style 0. Stigmas 3, large, flabellate-orbicular, spreading, plumose, reddish. *Male:* leaves smaller and slightly contracted at the middle. Flowers both axillary and terminal in simple short racemes ½in.–1in. long, 8–15 on a raceme, usually a single raceme in a sheath; pedicel very short, scarcely extending to mouth of sheath. Perianth-lobes obovate, cut nearly to base; tips rounded, incurved. Stamens exserted, spreading, straight and slightly flexuous; anthers white, sub-orbicular-elliptic, margined.

Hab. In same locality as the preceding species, *M. trilobata;* but neither of these species was commonly observed, while the larger species—"*M. adpressa*, Lab." (but ?)—abounds, attaining to a very large size, and forming impassable thickets; 1888: *W. C.*

Obs. This species is a more slender and implexed plant, and rises considerably higher, than *M. trilobata:* its smaller and fewer flowers, and entire strictly truncated and smaller leaves, arrest the attention at first sight when compared, and

are grave differential characters; besides, the reticulated venation of the leaves of the two species is very dissimilar.

Order LXVII.—THYMELEÆ.

Genus 1. **Pimelea**, Banks and Sol.

1. *P. rugulosa*, sp. nov.

Plant shrubby, prostrate, spreading, forming small compact low bushes; main stems rather stout, 1ft.–2ft. long, much branched; branches ascending and erect, 8in.–12in. long, stoutish, straight, sparingly hairy; hairs greyish, short, adpressed in small detached patches between the leaves, but never near their bases; bark pale reddish-brown. Leaves decussate, not close, about 1 line (sometimes 2) apart, patent, decurved, thickish, glabrous, sub-glaucous-green, minutely and regularly marked with light-grey scurf, sub-papillose on under surface, narrow oblong, obtuse, 2–3 lines long, margined; margins (and petioles) bright-red; midrib indistinct; floral leaves slightly larger and broader; petioles short, stout, glabrous, transversely wrinkled below. Flowers sub-terminal, capitate 3–5 together, sessile, closely compacted, with a thick bunch of erect white hairs at their bases. Perianth hairy, 3½ lines long, the lower half of tube rose-coloured turgid and rugulose, the upper portion slender and (with the limb) white; lobes broadly ovate, obtuse, spreading, recurved, longer than the white portion of the tube, their lateral margins slightly incurved. Stamens rather long, exserted; style much longer.

Hab. Open plains, Tahoraiti, south of Dannevirke, County of Waipawa; 1885–88: *W. C.*

Obs. A species having pretty close affinity with *P. prostrata*, Vahl., of which species Hook. f. gives no less than three indigenous varieties; but this plant possesses characters differing from them all.

Order XI.—CYPERACEÆ.

Genus 6. **Isolepis**, Br.

1. *I. novæ-zealandiæ*, sp. nov.

Plant very small, densely tufted, sub-erect, slightly branched at base; roots numerous, short, fine, wiry, red; culms and leaves green above, reddish below. Culms about 1in. long, leafy (3–4) below spikelet, semi-terete, channelled on upper surface, tips sub-acute. Leaves a little longer than culms, filiform, linear, much dilated and clasping at bases; tips very obtuse, drooping; leaf-sheaths (2 or more) loose, truncate, with a short erect obtuse point. Spikelet solitary, sub-sessile, lateral at or below middle of culm, small, ovate, about 1 line long (rarely 1½), few-flowered, elongating after flowering; and

the lower glumes and nuts falling off gives it the appearance of being peduncled. Glumes few, broadly oblong, 1 line long, concave, 1-nerved, nerve percurrent; centre green, thickish; sides straight, entire, very membranous; tips sub-acute, thickened. Stamens 3, long, flexuous. Nut minute, about $\frac{1}{78}$in. diameter, orbicular, tipped with a small point, black, finely papillose, slightly turgid, a little produced at base. Style long; stigmas 2, long, spreading, scaberulous.

Hab. Sides of watercourses in low grounds, Hawke's Bay; 1880: *W. C.* Also *Mr. A. Hamilton;* 1887.

Obs. This little plant is closely allied to another small New Zealand species, *I. basilaris*, Hook. f., but differs from it in its still smaller size, solitary spikelet, broader and fewer glumes with their mid-rib not "excurrent," orbicular black nut, and 3 stamens. This species is also allied to *I. acaulis*, F. Muell. (*Scirpus humillimus*, Benth.—"Fl. Austral.," vol. vii., p. 324).

Genus 14. **Carex**, Linn.

1. *C. picta*, sp. nov.

Rootstock hypogæous, creeping, very stout, woody, irregular, knotty and branched, coarsely covered with large striate brown imbricating scales. Leaves (and culms) pale-green, very narrow, linear-acuminate, ascending, flexuous, recurved, rather closely fascicled in fours, the outer leaf the broadest, truncate, sheathing 1in. from base, 3in.–6in. long, $\frac{1}{20}$in. wide at base, flat, smooth, 2-nerved, striate, upper surface channelled, tips filiform, obtuse, their margins minutely and closely (but not harshly) serrulate. Culms filiform, 3in.–4in. (rarely 5in.–6in.) long, sub-flexuous and ascending, drooping, sub-trilateral, striate, edges rounded smooth. Spikelets 1–3 (usually 2, very rarely 3), narrow ovoid and broadly lanceolate, rather slender, 3–4 lines long, shortly peduncled, dark-brown, bi-bracteolate; bracts erect, filiform, the lower $\frac{3}{4}$in.–1$\frac{1}{4}$in. long, the upper much shorter, one-third to one-fourth the length of the lower, coloured brown at base, with their basal margins much dilated; tips minutely serrulate (*sub lente*) as in leaves. Glumes large, very broad, orbicular-ovate, variegated, nerve at centre stout, bright-green, sides dark purple-brown, margins white and very membranous, pellucid, delicately and closely reticulate, extending beyond apex of nerve, tips rounded and sometimes emarginate; the lowest glume sub-aristate. *Male* flowers below occupying more than half of spikelet; anthers exserted, linear, very narrow, rather long, bright-yellow; stamens white, flexuous. *Female* flowers few; style very long twice the length of utricle, papillose-scabrid; stigmas 2, very long, spreading, flexuous and curly, brown. Utricle semi-terete, small, green (brown when quite ripe), broadly

lanceolate, beaked, many-nerved, glossy; margins of the upper half (not apex) largely serrate; tip truncate. Achenium lanceolate.

Hab. Half-concealed among low herbage, open grassy plains at Tahoraiti, south of Dannevirke, County of Waipawa; 1887: *W. C.*

Obs. This little species has pretty close affinity with *C. colensoi*, Hook. f. It is, however, a smaller plant, differing in several characters, particularly in its broader and flatter leaves, its fewer and slenderer spikelets, broader and tri-coloured glumes, with larger membranous margins, narrower and beaked utricles, long scabrid styles and stigmas, and narrow (not "orbicular") achenium (as shown in dissections of *C. colensoi*—"Fl. N.Z.," tab. 63B).

2. *C. polyneura*, sp. nov.

Plant loosely tufted, branched below, spreading, light-green. Culms erect, 7in.–9in. high, smooth, bluntly triquetrous, leafy. Leaves sub-rigid, linear very acuminate, 8in.–9in. long, ⅛in. wide near base, flat, smooth, shining, channelled, much striate (sub 22-nerved), sheathing; sheaths membranous, sub-truncate, bifid and sub-laciniate, coloured; ligule large, diagonal; keeled, upper portion of keel scabrid; margins slightly recurved and finely serrulate, most so at tips; tips filiform, acute, recurved. Spikelets 5–6, erect, axillary, bracteolate, rather distant, ½in. long, cylindrical, stoutish, obtuse, the lowest peduncled; peduncle slender, rigid, 1in. long; the top one wholly male, narrow, obovate; the others with few or no male flowers at their bases; the lower bracts long and leafy; the upper ones very narrow, short, erect. Glumes broadly ovate, bifid, purple, closely reticulated; margins membranous and finely laciniate; awned, awn as long as and longer than the glume, green, rigid, sharply and closely serrulate. Utricle longer than glume, sub-orbicular or broadly elliptic, 1 line long, turgid, smooth, shining, convex on the outer side, slightly concave on the inner, somewhat beaked, bifid, pale-greenish below, dark purple-brown above. Stigmas 3, short, pinkish, very scabrid. Anthers long, linear, brown; tips acute.

Hab. Edges of streamlets, woods, south of Dannevirke, County of Waipawa; 1887: *W. C.*

3. *C. longiacuminata*, sp. nov.

Plant large, dark-green, tufted with short surculi. Culms stout, erect, 2ft. 9in.–3ft. high, leafy, smooth, angles obtuse; bract-leaves long, the lowest longer than culm, 4 lines broad, keeled, margins and keel finely and closely serrulate. Leaves shorter than culm, same width, &c., as bracts, slightly rigid,

drooping at tops, finely acuminate almost setaceous, tips acute, many-nerved (sub 26), margins widely membranous below; the outer leaves much shorter and not so acuminate; the basal leaves very short, blackish, acute. Spikelets 6, erect and large, 1½in. long, stout, cylindrical, peduncled; the 2 lower very distant, the 4 upper close together, the topmost narrow and wholly male; each of the 5 lower ones with a few male flowers at its base. Sheaths long, 2in.–1½in. from nodes, closely adpressed. Stigmas 2 (sometimes 3), erect, stout. Glumes light-brown, glossy, very membranous, semi-pellucid, largely bifid; lobes laciniate aristate, arista long (very long on lower glumes, so as to cover the arista next above), green, sharply and strongly serrate. Utricle 1½ lines long, dark umber-brown, glossy, sub-rhombic-ovoid, turgid and slightly uneven, minutely scabrid (5–6) on upper margins, finely (almost obsoletely) striate; beak bifid, short, broad.

Hab. Low swampy ground, margins of woods, south of Dannevirke, County of Waipawa; 1888: *W. C.*

ORDER XII.—GRAMINEÆ.

Genus 2. **Microlæna**, Br.

1. *M. ramosissima*, sp. nov.

A large decumbent straggling and sub-ascending perennial grass, rising and creeping over low shrubs and bushes; dark-green; main stems as stout at base as a goose-quill, hard, solid, 7ft.–8ft. long, with several short sheaths at base, much branched; branches long, slender, leafy. Culms 4ft.–5ft. long, knotted; nodes 3in.–5in. apart, with long ovate-acuminate sheath-like bracts 2in.–3in. long, light-brown, nearly amplexicaul at outer base of each node, distantly leafy throughout, stout, cylindrical, solid, 2 lines diameter at base; the lower leaves 8in. long, $\frac{1}{10}$in. wide, linear acuminate, striate, many-nerved (5 of them being stout and prominent); margins minutely scaberulous, recurved and red; tip long, filiform; the upper leaves reaching close under panicle, 4in. long, very narrow almost filiform, $\frac{1}{20}$in. wide, acute; sheaths 2in. long, extending half-way between nodes, rigid, striate, with a few fine long hairs at the mouth; ligule small, semi-circular, somewhat chaffy, reddish, thickened. Panicle terminal, lax and sub-erect, 4in.–5in. long, narrow, distantly branched with 4–6 simple branches, each containing 3–4 pedicelled spikelets; pedicels long, ½in.–¾in., wiry, flexuous and (with rhachis) minutely scaberulous. Spikelet 8 lines long awns included, pale-green. Glumes, lowest pair small, persistent, whitish, spreading, the outer one very minute one-third the length of the inner which is about 1 line long, ovate, tip retuse and jagged; the 2 following empty glumes awned, unequal, the outer one 6

lines long, lanceolate-acuminate, 5-nerved, keel and margins scabrid, margins hyaline, with a small tuft of hairs at the base; the next 8 lines long including the long awn, narrow ovate-acuminate, 7-nerved, the awn long nearly ¼in., setaceous, straight, scabrid, acute; the uppermost or flowering glume 3-nerved, margins hyaline, the lower two-thirds entire, slightly scaberulous on keel, tip irregular jagged and scabrid; awn short and stout. Pale 3 lines long, linear-lanceolate, 1-nerved, tip obtuse, margins of the lower half entire, of the upper half and tip scabrid ciliate. Scales sub-flabellate or sub-quinquilateral, 7-nerved, tip produced, margins irregular and laciniate. Anthers 4, linear, 2½ lines long, both ends bifid, scarcely exserted. Stigmas long, diverging, ovate-acuminate, bushy, much branched, branches compound. Ovary oblong, sub-truncate. Grain not seen.

Hab. In a thicket on the banks of a small streamlet south of Dannevirke, County of Waipawa (and only in that locality); 1887–88: *W. C.*

Obs. This species is pretty closely allied to *M. polynoda*, Hook f., but differs from that species in several particulars—as, in its much longer and branched panicle, with long pedicels to the spikelets; in the tuft of hairs at the base of the inner pair of empty glumes, and in both of them being long-awned; in the difference in their nervature, in the tip of the pale being obtuse and ciliate; and in the form and nervature of its scales. It is, also, a larger and more robust plant.

Genus 12. **Apera,** Adanson.

1. *A. purpurascens*, sp. nov.

A tall erect and nodding densely-tufted graceful perennial grass, having numerous short stout striate sheaths, with long sub-aristate mucros at base. Stems slender, distantly leafy, knotted, striate, smooth, 2ft. long. Culms 3ft.–3ft. 6in. high, smooth, slender, nodding, purple above pale straw-colour below, 8in.–10in. long downwards from panicle. Leaves membranaceous, narrow, 9in.–10in. long, 1½ lines wide, sub-glaucous and striate above, edges and midrib slightly scaberulous, tips finely acuminate, setaceous; sheaths long, ciliate at top and margins; ligule membranous, truncate, produced in front, very short behind. Panicle large, nodding, pendulous, 2ft.–2ft. 10in. long, very open, loosely whorled, the lower whorls distant, 3in.–4in. apart, each containing 6–8 spreading capillary branches, the two largest 6in.–7in. long and twice whorled, their branchlets sub-rigid, angular, compressed, flexuous, scaberulous. Pedicels 4–5 lines long, wiry, flexuous, scabrid, thickened at tips. Spikelets small, $\frac{1}{10}$in. long, purple. Empty glumes longer than the flowering ones, sub-ovate-acuminate, 1-nerved with slightly scaberulous

keels; tips membranous, jaggéd; the outer very narrow and finely acuminate, the inner and larger one sub-aristate. Flowering glume ovate, 1-nerved, aristate; awn 3½ lines long, three times the length of spikelet, scabrid, flexuous and straight. Pale linear-oblong, tip obtuse, jagged. Stamen 1, short; anther narrow oblong, emarginate, cordate. Grain 1 line long, lanceolate, truncate.

Hab. Edges of streamlets in woods south of Dannevirke, County of Waipawa, flowering in February; 1887–88: *W. C.*

Obs. This is a truly elegant grass; and when it is found growing in large tufts among small ferns, in rather open spots on the borders of the streams, with a rich profusion of numerous gracefully-pendulous panicles, purple and glistening in the sun, it is a most striking object—one sure to rivet the attention of the privileged beholder. It differs in several characters from the other only known indigenous species of this genus, *A. arundinacea*, Hook. f., and is a far more handsome plant.

Genus 14. **Agrostis**, Linn.

1. (?) *A. striata*, sp. nov.

A small slender erect glabrous annual grass, 5in.–6in. high; stems with 3–4 distant nodes. Leaves few, on stems 1½in. long, $\frac{1}{80}$in. wide, striate; margins minutely scaberulous (*sub lente*); ligule long, narrow, sub-acute, erect, hyaline, jagged at tip. Panicle erect, open, free, 3in. long, rhomboid in outline, distantly whorled, the lowermost having 5 unequal capillary rigid flexuous branchlets, the largest being 1½in. long and whorled about the centre, all minutely scaberulous; each branchlet usually bearing 2 distant spikelets; pedicels much thickened at base of spikelet, that of the lower spikelet short, of the upper long. Spikelets $\frac{1}{10}$in. long, membranous, whitish, shining; the two empty glumes nearly alike, much spreading, sub-linear-lanceolate, acuminate, very acute, tips purple, nerveless, but with many longitudinal minutely zigzagged purple striæ forming linear cells, scabrid on back and at margins which are hyaline. Flowering glume small, oblong, sub-truncate, $\frac{1}{18}$in. long, striate, 3-nerved, greenish, hairy, awned, a small lateral tuft of hairs on each side near base; tips laciniate, jagged, and very hairy with long spreading hairs; awn short, stout, coarsely scabrid, springing from one of the lateral nerves a little way down the back. Anthers oblong, truncate, emarginate. Grain ½ line long, sub-oblong-lanceolate, obtuse, narrower at apex, turgid, shining, pale ochraceous.

Hab. High lands in the interior near Lake Waikare, County of Wairoa; 1888: *Mr. H. Hill.*

Obs. This curious little mountain species is widely different

from all of this genus known to me; hence I have provisionally placed it here. I have only had a few half-withered and somewhat imperfect specimens for examination, which seem to have been accidentally collected with other small herbs.

ART. VI.—*Notes on a Plant* (Glossostigma elatinoides) *found beside the Maungapouri Stream, Otaki.*

By CLEMENT W. LEE.

[*Read before the Wellington Philosophical Society, 22nd August, 1888.*]

Glossostigma elatinoides, Bentham.

THIS plant is not uncommon in New Zealand, and I have lately found it beside a stream near Patea. It seems to grow so close to the water that at freshes it may be entirely submerged. It has been reported from Auckland, Nelson, and Southland.

The plant is a perennial creeper, flowering from November to March. It grows very close to the ground and very thickly.

Its botanical description is as follows:—

Root fibrous, springing from axils of leaves.

Stem prostrate, smooth, green, running; leaves and roots springing from nodes 1in. apart.

Leaves opposite, 2 at each node, succulent, simple, entire, obovate, pale-green, ⅓in. by ⅙in., petioled.

Flowers: Calyx regular, monosepalous, inferior; corolla irregular, monopetalous, campanulate, 3- and 2-toothed, creamy-white; stalk 1in.

Stamens definite, 4, epipetalous; anthers ovate, brown, erect, opening longitudinally.

Pistil leaf-like, spathulate, covered with minute spikes, *at times curved over stamens.* When touched gently, turns back and lies against the petals; being the same colour, it is then difficult to perceive. After being opened unnaturally, closes again in about a quarter of an hour.

Ovary superior, 1-celled (?).

Style long; stigma and style in one.

The peculiarity which distinguishes this curious little plant is that upon touching the pistil, which forms a kind of hood over the stamens, it rises up and falls back upon the petals, so closely fitting as not to be seen without trouble. This action leaves the stamens exposed to view.

Upon examination of many plants, I found that in about fifteen minutes after being disturbed the pistil resumes its former position.

The experiment can be repeated an indefinite number of times, I believe. The pistil will not remain over the stamens if pushed there.

It would seem as if there is a spring of some sort—if one can call it by that name—in the pistil, but as yet the microscope has not revealed it to me.

I am inclined to the view that this movement of the pistil is intended to produce cross-fertilisation, or to produce fertilisation at all. An insect alighting upon the pistil would probably cause it to turn back and so expose the pollen; this would be carried away and deposited on the next flower visited. The spikes with which the pistil is studded would facilitate this. I have, whilst examining the pistil, found grains of pollen adhering.

The pistil would close after the insect's visit, thus preserving the remaining pollen.

I noticed on the 30th January that all the flowers I got and examined had their pistils turned back, and so remained until the flower died.

After reading some papers by Mr. G. M. Thompson on cleistogamic plants, I have thought that this plant might be one in which self-fertilisation takes place, and until that had taken place the pistil remained over the stamens, and that when the organ had fulfilled its function it lay back for good. Upon further observation of a single flower, I noticed that, when water was poured round the plant so as to completely submerge it, the pistil, which was turned back upon the petals, closed over as the water reached it, and remained so, covering the stamens until the water was removed, when it again opened back.

A question still remains: Would pollen deposited upon the outside of the pistil fertilise the plant? If so, the insect carrying pollen would be obliged to leave some in opening the next flower visited.

The peculiar position of the pistil may be a wonderful contrivance for preserving the pollen from being washed away when the plant is submerged, as must often be the case.

The foregoing note has been drawn up as containing certain points of information, botanical description, &c., on this curious little plant which are not noticed in Mr. Cheeseman's paper, in vol. x. of the "Transactions,"* on the springing-back of the pistil. This feature is also of so exceptional a character that even repeated accounts of it are interesting.

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* "Trans. N.Z. Inst.," vol. x., art. xlvii., p. 353.

Art. VII.—*The Fall of the Leaf.*

By Joshua Rutland.

Communicated by Professor Hutton.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1888.*]

Why deciduous trees prevail in the north temperate zone and evergreens in the south is a question which can scarcely fail to intrude itself on any one, however uninquiring, whose experience enables him to institute a comparison between the forests of the two regions in their respective winter periods.

To the emigrant from Britain, whose home is amidst the wilds of the New Zealand bush, the contrast is most apparent. Surrounding himself as he generally does with the plants of his native country, he sees them unaltered in their habit side by side with the indigenous productions, whilst he is constantly reminded by the cold winter nights that the climatic conditions of his old and new homes do not differ very widely. Hence the reason why this difference is forced upon and kept ever before him.

The mere fact of northern species remaining unaltered when removed to corresponding southern latitudes, and *vice versâ*, is sufficient to show that an answer to this question is not to be found in the existing conditions of soil or climate, while the exceptions that occur in both hemispheres prove that the deciduous and non-deciduous habit cannot be entirely due to the nature of the plants that constitute the respective floras.

For example: We have in Europe the guelder-rose (*Viburnum opulus*) and the laurustinus (*Viburnum tinus*), belonging to a purely northern genus, the former deciduous, the latter evergreen; and in New Zealand the ribbon-woods (*Plagianthus betulinus* and *P. divaricatus*), evergreen or deciduous according to the situation in which they grow, the only other species of this genus being Australian.

As the fall of the leaf, which is the subject of this inquiry, always takes place at the approach of or during winter, we are justified in concluding that a lowering temperature is the immediate or most important cause of it. The problem we have then before us is, why are not the effects more uniform?

For the examination of these effects there are probably few places that offer such facilities as the Pelorus District, wherein I now write. In the narrow bush-valleys and their numerous branches, with encircling hills running into peaks of 3,000ft. elevation, and in the long, narrow, sheltered sound, though extremely limited in extent, we meet with a variety of

climatic conditions stamped so plainly on the surrounding vegetation that even the most incurious cannot fail to notice them.

That plants cease to grow or increase in volume when the temperature of the air and soil fall below a certain point is too well known to require more than mention; but the degree of cold at which growth ceases varies extremely when many species are observed. For instance, some plants grow only during the warm summer months; others, again, lie dormant during that season, as many of our cultivated bulbs, putting forth their leaves and flowers in autumn, in spring, and even in winter.

That there is a degree of cold which will put each species to rest, and another which would terminate its existence, may, I think, be safely assumed. Between these two effects—the suspension of growth, and death—other effects—the fall of the leaf, and the destruction of the overground portion or ascending axis of the plant—sometimes take place.

Evidently some species are incapable of exhibiting the last-mentioned phenomena, death immediately following the suspension of growth.

Taking again our former examples—the laurustinus and the guelder-rose—we commonly see those shrubs growing together in our gardens, the former in full leaf when the latter is quite bare. A further diminution of temperature, instead of assimilating the appearance of these species, would destroy the laurustinus, leaving the guelder-rose uninjured.

We thus arrive at the conclusion that the evergreen habit may be absolute or conditional; and, secondly, that, though a species may remain unaltered when exposed to a temperature which deprives others of their leaves, the latter may be the hardier, or capable of surviving through the greatest degree of cold.

Of the absolute and conditional evergreens this district furnishes some instructive examples. Thus, the *Olearia hectori*,* evergreen in other parts of the colony, is a deciduous shrub in the Pelorus Valley, where it grows in low situations outside the bush, associated with *Plagianthus betulinus*, *Sophora tetraptera*, and *Fuchsia colensoi*, which are also deciduous.

Again, along the shores of the Pelorus Sound the karaka (*Corynocarpus lævigatus*) is very plentiful; but, finding that it did not occur in the inland valleys, I some years ago raised plants from seed, which were immediately cut to the ground by the first severe frost, and thus destroyed. In this case the

* For the identification of this and many other species I am indebted to the kindness of Mr. T. Kirk, F.L.S.

deep, cold soil of the Pelorus Valley assisted, I have no doubt, in producing the results; still, the fact remains that death followed the suspension of growth without the intermediate effects. From this example we also learn how very close to the verge of their climatic range species are sometimes to be found.

Among deciduous trees the time at which the leaf falls varies *considerably* when a comparison of species is made, and *slightly* in the case of individuals of the same species. Thus, in this part of these islands the walnut, ash, Lombardy poplar, and others begin to shed in April, and are quite bare early in May. The weeping willow (*Salix babylonica*), on the other hand, retains its leaves till June—sometimes to the shortest day. But the retention of its leaves by the latter species depends to a certain extent on the situation in which the trees grow: for instance, where the roots are in contact with running water the leaves turn yellow and fall earlier than do the leaves of trees occupying warm ground. We can thus see that the fall of the leaf is hastened, in species capable of assuming the deciduous habit, by the condition of the soil, just as death is hastened in the case of the absolute evergreen species.

As might naturally be expected, species which lose their leaves early in autumn resume them late in spring, and *vice versâ*. To this general rule I have observed a marked exception—the lemon-scented verbena (*Aloysia citrodora*), which is here deciduous. Though this tree never sheds its leaves before the end of May, and sometimes retains them till the middle of June, it is, of all my cultivated species, the last to come back into leaf. From the peculiar behaviour of this plant I long suspected that in a slightly milder climate it would become an evergreen: this conjecture I found to be correct, for at The Rocks, Queen Charlotte Sound, a specimen during several winters remained in leaf. The distance between the Pelorus Valley and The Rocks being less than twenty miles in a direct line, the climatic difference must be very small; still, it is sufficient to turn the scale from a deciduous to an evergreen habit, and, as we shall presently see, from a herbaceous to a deciduous or semi-evergreen habit.

This last example shows how the deciduous habit may be reversed as well as induced, and, though exact experiments are wanting, there is good reason for believing that the process of reversion, or converting deciduous into evergreen plants, is possible in all cases, though the capacity for assuming the deciduous habit is confined to a limited number of evergreen species. From this we might conclude that the evergreen is the original form, a conclusion which is strengthened by the fact that certain deciduous species are evergreen when young.

The passage of the deciduous plant into the herbaceous

under the influence of cold can be well observed amongst our cultivated fuchsias, some of which in this climate merely lose their leaves, while others have their stems wholly or partly cut off. Of several varieties I find *Fuchsia fulgens* the most susceptible of cold. It is the first to shed its leaves on the approach of winter, during which the stems are invariably destroyed, even when the plants are kept within the shelter of a verandah; yet a specimen taken from here to the Rocks, before mentioned, retains not only its stems, but a portion of its leaves, and on one occasion I noticed it in flower during the winter months.

One more effect of cold—the dwarfing-down of vegetable forms—requires mention. This is well illustrated by our *Alseuosmia macrophylla*, which in the North Island is a bushy shrub 4ft. to 5ft. in height, but here rarely exceeds 1ft., the stem being seldom branched.

From the foregoing considerations and examples we seem to arrive at the following general conclusions: That, though the majority of existing evergreen plants would at once perish were the temperature of the air and soil in which they grow reduced below a certain point, a few, owing to some structural peculiarity, would shed their leaves or suffer the loss of their stems before they finally succumbed, and that in this latter fact we have the immediate origin of the deciduous tree.

The effects of cold consequent on the changing seasons and the effects produced by the artificial removal of species from their proper habitat to higher latitudes, come within the scope of observation and experiment; but we have now to consider a portion of our subject of a more speculative character—namely, *the effects of a lowering temperature through climatic changes.*

That various portions of the earth's surface have, during different periods of their history, been subjected to very different climatic conditions is one of the most important facts made known by the researches of geologists. In Europe, where the grape now ripens the reindeer once roamed; and here, in the Wairau Valley, within a few miles of where I write, are the moraines of an ancient glacier shown in the Upper and Lower Travers hills, the latter being only about 1,000ft. above sea-level.

The climatic changes which the earth has undergone are plainly referable to two causes. One, alteration in the elevation of the land, converting low land into alpine climates, is easily understood; the other, though its operation has been on a much more extensive scale, remains, as far as I am aware, yet undiscovered. I refer to the Glacial Period, that followed after the deposition of the tertiary rocks in the northern hemisphere.

We cannot from observation explain the formation of alpine floras, but wherever they exist we see that they correspond in their general aspect with the flora of the surrounding region. Thus, the mountains of Australia and Tasmania are clothed with plants essentially Australian, evergreen trees ascending to the limits of arboreal vegetation. In like manner, typical New Zealand species—such as Veronicas, Coprosmas, and Pittosporums—are found in our alpine heights. Nor do the few deciduous trees we possess particularly affect those elevated regions. One only seems to owe its deciduous habit to the alpine cold, *Plagianthus lyalli*, which the late Sir J. Haast observed as "a deciduous tree at and above 3,000ft., but evergreen below that line."

The two allied species, *Plagianthus betulinus* and *P. divaricata*, both deciduous, belong to the lowland country; the former, in this district, invariably growing on the low rich land of the inland valleys, the latter fringing the tideway throughout the sound. A careful scrutiny of the flora of any extensive and varied region will at once reveal the fact that the horizontal and vertical range of species do not always coincide, for it is not the plants of the highest latitude which are invariably found closest to the summits of high mountains. The reason of this becomes apparent when we examine the distribution of the plants within any limited mountainous district traversed by deep valleys, bearing in mind as we do so what has been so clearly pointed out by Liebig in his "Natural Laws of Husbandry"—viz., that "all plants which give landscapes their peculiar character, clothing the plains and mountain-slopes with perennial green, have an underground development, according to the geological or physical condition of the soil, admirably adapted to their perennial existence and propagation." In this district, for example, we have two very distinct classes of land, the low alluvial flats of the valleys, and the steep hill-sides, with an intermediate class consisting of level terraces, composed of rock-fragments imbedded in gravel and clay.

Now, in the alluvial flats and hill-sides respectively we find certain species of plants which never encroach on each other's territory, though most of them intermingle on the terrace lands. Amongst those which most strictly adhere to their proper habitat are the deciduous *Plagianthus betulinus* and *P. divaricata* before mentioned. As both species range to the southern portion of the island we are forced to conclude that it is not inability to withstand cold, but an inability to adapt themselves to any other than the deep soil in which they invariably grow, that determines their vertical range.

It can thus be seen how, in the process of selection which must take place through the elevation of a portion of a

hitherto low-lying region clothed with evergreen vegetation, and the consequent climatic changes, other causes beside the mere lowering of temperature would assist in determining the upland flora, and that amongst the species thus selected those capable of assuming the deciduous habit might be only in part included, or might be wholly omitted.

We may now turn to the second class of climatic changes to which portions of the earth have been subjected. Though the causes which operated to bring about the cold of the European glacial period are unknown, there is abundant evidence that prior to its commencement that continent enjoyed a climate as mild as, or milder than, at present prevails. Whether during this pre-glacial epoch an evergreen vegetation clothed the plains and mountains cannot well be determined, but the fact that Australian forms are found amongst the fossil-plants of the Swiss miocene rocks at least suggests that the flora of the northern and southern hemispheres did not differ as widely then as now.

Assuming that Europe at the close of the tertiary epoch supported a vegetation similar to what is now found in corresponding southern latitudes—that evergreen trees, with a small percentage of deciduous forms, then prevailed—let us ask what would have been the effect of the coming-on and subsequent passing-away of the glacial cold.

Before approaching this question it may be well to review what is known of the glacial period. That movements of upheaval and subsidence on a considerable scale took place in Europe during the continuance of the glacial cold is evidenced by the deposits of the period and the present distribution of animal life on the continent and adjacent islands.

Thus, in the commencement of the period when the cold was most intense, the continent extended westward of the area now occupied by the Hebrides and Ireland, the land being generally higher than the existing islands.

Towards the middle of the period a movement of subsidence commenced, and continued until only what are now the tops of the highest British mountains remained above water, forming an archipelago of small islets, amongst which drifted masses of floating ice, depositing where they grounded quantities of *débris*, which still remain on the mountain-sides in the form of stratified deposits, containing marine shells. This movement of subsidence was followed by one of elevation which brought the British Islands to their present level. As the land rose, the cold, which had abated during the downward movement, again increased, though not to what it had previously been. Although the greatest cold of the glacial period in Europe was coincident with the greatest elevation of the land, we cannot in any way ascribe the great climatic

changes to alterations of level. Indeed, the most with which we can credit the movements referred to is that they may have helped to bring about the fluctuations of temperature which took place, the minor acting in conjunction with the major cause.

By picturing to ourselves an extension southward of the Arctic regions, and a consequent narrowing of the temperate zone, with a subsequent movement in the opposite direction, we shall probably obtain a fairly correct idea of the climatic changes which took place in Europe between the commencement of the quaternary epoch and our own time. Obviously the effect of those changes, as selective and differentiating agencies, on the vegetation of the region must have been very great. As the temperature lessened, the power of endurance in every species would be tested to the utmost, and all the phenomena displayed by plants under the influence of cold would be exhibited, such as the dwarfing-down and the assumption of the deciduous habit, or, to borrow a term from the zoologist, passing into a state of *chill coma.*

During this ordeal many species would inevitably perish, and some hitherto evergreen would become deciduous; thus the proportion of the latter to the former would be increased.

Here the question naturally arises, would the deciduous tree have any advantage over the evergreen while these climatic changes were taking place? Or, to put the question in another form, beside the mere loss of vital energy, would the evergreen tree suffer in any way through the lowering temperature while the deciduous form escaped? This, I think, may be answered in the affirmative; for in the winter of 1860 a light fall of snow which visited the Pelorus Valley destroyed numbers of trees throughout the bush, owing to their not being able to sustain the unusual weight. Judging by what then happened, I am satisfied that, were a tithe of our winter rainfall converted into snow, the mixed forests in this district would completely disappear in a few years. On the destruction of the larger trees would follow the death of the undergrowth to which they afford shelter, and which in turn protects the all-pervading surface-roots of its protectors.

Once broken into, and the surrounding conditions permanently changed, our mixed forests are doomed: this the effects of the removal of timber for commercial purposes and the running of cattle in the forests daily teach us.

None of our deciduous trees except the generally-diffused *Fuchsia excorticata* being found within the precincts of the bush suffered from the fall of snow referred to. Their slender, naked branches could not accumulate a sufficient weight to cause breakage; while, not being overshadowed by loftier trees, they did not incur danger from falling timber. Our

Plagianthus betulinus and *Sophora tetraptera*, growing as they do in small groves, the trees far apart and interspersed with brambles—*Rubus australis* and other tangled bushes—invariably recall the woods of the mother-country when observed in winter.

That these deciduous trees would soon overspread much of the low land in this valley were the mixed forest removed, and thus give a more boreal appearance to the district, is shown by the abandoned clearings made by the natives prior to the introduction of cattle and foreign weeds.

Whatever may have been the nature of the European flora at the commencement of the glacial period, when the cold attained its maximum the aspect of the region would be completely altered. What was previously, and is now, the north temperate would be included in the frozen zone, and the limit of arborescent vegetation removed far south.

Having evidence that the reindeer then roamed throughout central France, we cannot give to the shores of the Mediterranean a climate milder than is at present enjoyed by the British Islands. Thus shorn, as it were, of the most genial portion of its climate, the vegetable production of Europe would be correspondingly reduced. Only those species capable of withstanding severe cold and of adapting themselves to every variety of soil could survive the southward movement of the flora enforced by the climatic changes.

As we have seen that the tendency of the lowering temperature would be to induce the deciduous habit, and that in the struggle for existence during the increasing cold the deciduous would have a certain advantage over the evergreen tree, I think we may reasonably conclude that, however largely the latter preponderated in the upper tertiary flora, in the remnant that survived the glacial period the proportion would be greatly altered, perhaps reversed.

A comparison of the British flora with that of New Zealand reveals, besides the deciduous habit of the arborescent species, so frequently referred to, other general differences that demand explanation. For instance, though the phanerogamic plants of the British Islands exceed those found within the New Zealand group, the latter flora contains a much larger number of arborescent forms, while, again, the British species belong to fewer genera and fewer orders than are represented in New Zealand. In the northern flora we seem to have the more or less altered descendants of a few original types, in the southern flora the waifs and strays from some rich and varied botanical region.

As the glacial cold abated, as the snow disappeared from the mountain-heights and the plains were freed from their

icy bondage, the soil capable of supporting vegetable life would demand forms suitable to its varying condition. To supply this demand there would be the scanty remnants of the tertiary flora before referred to—for Europe, cut off from the warmer regions of Africa by the waters of the Mediterranean, would be more dependent on these resources than if it were a portion of an uninterrupted mass of land stretching southward to the torrid zone.

When commenting on the unavoidable destruction of the tertiary species by the glacial cold, I pointed out that deciduous trees would probably form a conspicuous feature in the surviving remnant. Another peculiarity of this remnant would be the preponderance of herbaceous plants; for wherever we observe the effects of a low temperature, whether in high altitudes or high latitudes, we find a larger number of herbaceous than arborescent species.

As Europe, when the glacial cold was at its height, lay entirely within the colder regions of the earth, we may fairly conclude that this was one of the characteristics of its vegetation.

If we now suppose the European continent, as its climate gradually improved, to be reclothed with vegetation by its glacial flora, through a mere multiplication of the individual plants, we can readily imagine how monotonous would be the effect. But such a result would be impossible, for in so diversified a region, and with constantly changing climatic conditions, expansion could not take place without giving rise to variation. New varieties and species would thus appear, the flora being thereby enriched in forms specifically distinct, but belonging to a few generic and ordinal types.

Returning to the British flora, we can now see how the various points in which it differs from the corresponding southern flora—the prevalence of deciduous trees, the preponderance of herbaceous plants, and the comparatively few orders represented—seem capable of explanation by the effects of the glacial cold.

If the prevalence of deciduous trees in the north temperate zone is the result of certain former climatic conditions, it necessarily follows that the vegetation of the southern zone has not been subjected to similar conditions.

To what, then, must we refer the evidence of ice-action in parts of these islands where light falls of snow now rarely occur?

To this question I shall not venture a reply, not having a sufficient knowledge of the geology of the southern hemisphere. I may, however, state that the glacial moraines of the Wairau Valley before mentioned might be accounted for by a former elevation of the land. That the land throughout

this portion of the globe was at some former period more elevated than at present is proved by the distribution of the fauna. For example, Tierra del Fuego and Tasmania must have formed integral portions of the adjacent continents, and the various islands of the New Zealand Archipelago, including the Chathams and Lord Howe Island, were directly or indirectly connected. Still, even if we could show that the evidences of ice-action now observed were due to the period of elevation, it would not in any way prove that the southern hemisphere has not undergone climatic changes similar to those which took place in the north. There is no reason to look for such a difference in the histories of the two regions; for a careful consideration will enable us to perceive that, if the distribution of land and water during that time was analogous to what it is now, the glacial cold may have been simultaneously experienced in both hemispheres, though its traces cannot be readily discovered in the southern vegetation.

For instance, were the island of South Georgia, situated in a latitude corresponding with the north of Scotland, to become capable of supporting vegetable life, it would require stocking from entirely foreign sources. Being at present enveloped in ice to sea-level, it is, of course, destitute of vegetation. A flora having such an origin could afford no direct clue to the former history of its region. If during the glacial period the climates of the northern and southern hemispheres bore the same relation to each other as at present, the condition of the New Zealand Islands, supposing they existed, must have been analogous to that of South Georgia. At most, a scanty vegetation might have been found in the low lands in the northern portion of the group. Under these circumstances the present flora must be chiefly of recent foreign origin, and we discover in it certain general characteristics that seem to favour this view. For instance, the tropical nature of the forest-vegetation, so frequently remarked, has been always accepted as evidence of a former distribution of land which enabled a more northerly flora to extend its range southward. On the other hand, our open lands and mountains furnish numerous species which might belong to colder climes in a colder period. Nor is the presence of plant-remains allied to our forest-vegetation in deposits older than the glacial period necessarily opposed to the recent introduction of this portion of the flora, for there is good evidence that a portion of the vegetation removed by the glacial cold in Europe returned to its old habitat. Thus, in an upper cretaceous deposit at Aix-la-Chapelle, associated with fossil remains of *Pandanaceæ* and *Proteaceæ*, are species of the genera *Quercus* and *Juglans* now proper to that part of Europe. Though a rigorous process of selection and much differentiation has taken place between

the present and the pre-glacial flora, a connection is clearly traceable.

Whether we confine our attention to limited regions or extend our observations over the earth, we find everywhere that the main features of the vegetation are due to climatic influences. Thus, in these islands we meet with contiguous and sharply-defined districts clothed with dense bush or associated grasses denoting differences in the rainfall. These features we see repeated on a grand scale in the vast forests of the torrid zone and in the broad savannahs and prairies of colder latitudes.

Again, we have wide tracts, subject to long periods of drought, tenanted almost exclusively by annuals, the adaptation to climate being therein evident; and in hot countries where very dry and wet seasons alternate, we have the curious phenomenon of heat-coma, displaying itself by the shedding of leaves.

Among climatic causes, then, it seems as if a reason for the distribution of deciduous and evergreen trees must be found; but, no existing conditions throwing any light on the matter, I have sought an explanation in such records as we have of the past—with what success I must let others, with more knowledge, judge, for as I close these pages I am fully sensible of having undertaken a task for which I was very inadequately prepared. The solution of the question having been, as far as I am aware, hitherto unattempted, if I merely succeed in directing attention to it I shall consider I have done well.

II.—ZOOLOGY.

Art. VIII.—*On some Birds from the Kermadec Islands.*

By T. F. Cheeseman, F.L.S.

[Read before the Auckland Institute, 24th September, 1888.]

In my paper on the flora and fauna of the Kermadec Islands, printed in the recently-issued volume of "Transactions of the New Zealand Institute,"* I have given a list of the birds observed during my short stay in the group. Since then Captain Fairchild has made a second visit to the islands, and has obtained some additional specimens, which he has very kindly placed in my hands. Mr. Bell, the resident on Sunday Island, has also forwarded to the Museum a collection of birds' eggs, accompanied with some interesting particulars respecting several of the sea-birds which frequent the island for breeding purposes. From these sources of information I am now able to record the presence of two species new to the New Zealand fauna, and to prove that a third, hitherto only known as an occasional straggler in our waters, breeds regularly in the Kermadec group.

1. *Sula cyanops*, Sundevall (Masked Gannet).

In my list I briefly alluded to the presence of a fine gannet differing from the species common all round the North Island in wanting the buff-coloured feathers on the head. From the deck of the "Stella" it was noticed to be breeding in some numbers on the top of Curtis Island, but, as bad weather compelled Captain Fairchild to put out to sea before an ascent of the cliffs could be made, I was unable to procure a specimen. During his last visit, however, Captain Fairchild was more fortunate. He reached the summit of the island, and, finding the birds breeding there as before, caused four of them to be taken off their nests and carried on board the steamer. Thanks to his care, all four reached Auckland alive. On examining them it was evident that the species was that known as the masked gannet (*Sula cyanops*), which has a wide range in tropical seas, but had not been previously found on the coast of New Zealand. As mentioned above, it is at once distinguished from our common gannet (*Sula serrator*) by the head and neck of the adult bird being perfectly white,

* "Trans. N.Z. Inst.," vol. xx., art. xxiii., pp. 169–5.

and presenting no trace of the beautiful buff-yellow so conspicuous in *Sula serrator*. It is also rather smaller, and the shape and colour of the bare skin at the base of the bill are different. In the masked gannet the bare skin extends a little beyond the corners of the mouth, and then crosses the throat in an almost straight line, while its colour in the adult bird is a deep blackish-blue. This dark colour contrasts vividly with the snow-white feathers of the head and neck, and is doubtless the reason why the bird has received the common name of the "masked gannet." In *Sula serrator* the bare skin is continued under the throat for a considerable distance in the shape of a narrow triangular stripe, and its colour is a pale leaden-blue.

Like our species, it forms no true nest. On Curtis Island its single egg was placed in a slight depression among the scanty tufts of short grass which form the chief vegetation on the top of the island. The females are quite exposed while sitting on the nest, and from their white plumage form very conspicuous objects; but, as they are strong and powerful birds, well able to defend themselves from all enemies, their exposed position is probably no real disadvantage to them.

Few birds have a wider geographical range. Drs. Finsch and Hartlaub, in their well-known book on the avifauna of Central Polynesia, state that it has been found in the following localities: The Atlantic Ocean, near Ascension Island; the Red Sea; Cocos Island; the Straits of Sunda; Torres Straits and North Australia; Polynesia, from the Sandwich Islands southwards to Samoa, and westwards from the Paumotu group to the New Hebrides. It seems probable that it also exists on the coasts of both North and South America.

2. *Gygis candida* (Silky White Tern).

While conversing with Mr. Bell respecting the birds of Sunday Island he alluded to a small white tern which visits the island every November to breed. From his description of the plumage, &c., and account of its breeding-habits, I concluded that it would probably prove to be this species. During the last breeding-season Mr. Bell made further notes on it, and has now sent me these, together with specimens of the egg. As his notes, and the shape, size, and colour of the egg agree exactly with the published accounts of *Gygis candida*, I have now no hesitation in considering it to be that species. The bird, which is a most beautiful one, is rather smaller than our common tern (*Sterna frontalis*). It has a slender body, long wings, and deeply-excised tail. The whole of the plumage is pure-white, and of silky softness. The bill is long and curved slightly upwards, dark-blue at the base, shading off into black at the tip. Its breeding-habits are peculiar. Mr.

Bell writes, "It lays its solitary egg high up on the pohutukawa trees, on a horizontal branch not much thicker than a man's wrist. The bird sticks to the egg and keeps it in its place until it is hatched." This statement is corroborated by what is known of its habits in some other localities. Mr. Cuming, the well-known conchologist, observed it on Elizabeth Island, and says, "It was breeding on a kind of *Pandanus*, its single egg being deposited on the horizontal branches, in a depression which, although slight, was sufficient to retain it in position despite of the high winds and consequent oscillations to which it was subjected." Mr. Cuming adds that the old birds were flying about in thousands like swarms of bees, and that he noticed several breeding on the same tree. Several young birds were observed lying dead on the ground, from which it appears that they frequently drop from their dangerous resting-place. However, it does not always breed on trees; for Dr. Graffe, a German collector, found it resting in hollows of the bare rock on one of the islands of the Phœnix group.

Gygis candida is found throughout the whole of Polynesia, along the Australian coasts northwards to Torres Straits, and from thence through the Malay Archipelago to India. It has also been recorded from the west coast of Africa.

3. *Phaeton rubricauda*, Bodd (Red-tailed Tropic Bird).

This beautiful bird, so familiar to all voyagers in the warmer parts of Polynesia, has long been known to breed as near to New Zealand as Norfolk Island, and occasional stragglers are at long intervals captured by the Maoris residing near the North Cape, usually after a succession of heavy northerly gales. Few Europeans, however, have seen it in New Zealand waters, and the only specimen obtained, so far as I know, is one shot by Mr. Henry Mair near the Three Kings Islands, and now in the possession of Sir Walter Buller.

When at the Kermadec Islands last year Mr. Bell informed me that the tropic bird breeds regularly on Sunday Island, arriving in October and remaining until the close of summer. I therefore inserted the species in my list on his authority. I have now received from him several roughly-prepared skins and some eggs which prove that it has been correctly identified. Its appearance, habits, and geographical distribution are too well known to require mention here.

The following record of the temperature at Sunday Island in 1887–88 has been made by Mr. Bell, and forwarded by him to Mr. Percy Smith, Assistant Surveyor-General. As no meteorological observations of any kind have been pre-

viously taken in the group, it is perhaps worth insertion here :—

I. Mean temperature in the shade, taken from daily observations made at 9 a.m. :—

	°		°
January	77·4	July	62·1
February	74·6	August	64·0
March	74·9	September	68·5
April	69·4	October	68·3
May	68·1	November	72·6
June	65·0	December	75·3

Mean for the year, 70°.

II. Occasional readings of the thermometer taken at noon :—

	Shade.	Sun.
Jan. 3	85	107
„ 5	87	110
„ 15	88	104
„ 16	89	Cloudy
„ 17	91	110
„ 18	91	110
„ 19	94	111
„ 20	94	112
„ 22	95	120
„ 25	90	114
„ 31	88	Cloudy
Feb. 9	85	100
„ 11	90	108
„ 16	87	104
„ 27	86	102
Mar. 16	85	101
„ 20	87	100
June 14	70	90
„ 22	70	89
July 1	69	87
„ 29	67	90
Nov. 14	84	94
„ 22	94	104
Dec. 4	85	102
„ 12	83	106
„ 19	87	102
„ 24	84	100
„ 28	89	100

ART. IX.—*Notice of the Capture of a Specimen of the Shy Albatross* (Diomedea cauta) *near Auckland.*

By T. F. CHEESEMAN, F.L.S.

[*Read before the Auckland Institute, 2nd July, 1888.*]

So far as I am aware, only two instances are on record of this rare bird being obtained in New Zealand. Some time in 1876 a specimen was captured in Blueskin Bay, Otago, and came into the possession of Professor Hutton, who was at that time in charge of the Otago Museum. Professor Hutton identified it as the Shy Albatross, or *Diomedea cauta;* and I believe the specimen still exists in the collections of the Museum. In July, 1887, another example came ashore near the pilot-station, at the entrance to Wellington Harbour. It was secured by some fishermen, and ultimately passed into the hands of Dr. (now Sir Walter) Buller. In the tenth volume of the "Transactions" an account will be found of the circumstance, and a full description of the bird.*

About six weeks ago Mr. D. Bate, of Brighton, Parnell, informed me that he had an albatross differing in plumage from any of the stuffed examples in the Museum. On calling to see it, I found that it was undoubtedly a male, in full plumage, of the Shy Albatross. Mr. Bate informed me that a friend of his, while shooting curlew by the side of the Manukau Harbour, near Penrose, observed the bird in a grass-paddock. Albatrosses are unable to take flight from a level piece of ground, so that there was no difficulty in approaching it; in fact, it could do little more than waddle about in a circle. Concluding that it was injured, an attempt was made to seize it by the neck. This was evidently done in a most incautious manner, for I am informed that the bird retaliated by seizing its assailant by the lower part of the nose, inflicting a severe tear. However, it was at length captured and despatched. Mr. Bate has kindly presented the specimen to the Museum, so that I am able to exhibit it to you this evening.

The Shy Albatross is easily distinguished from all the other species by the beautiful pearl-grey feathers of the face and neck, and by a narrow yellow line at the base of the bill. This latter character can only be observed in living specimens, although conspicuous enough in them; the membrane soon losing its colour after death. Very little is known of its habits. Unlike the other species it is not at all bold, and seldom approaches ships. Nothing is known of its breeding-places, nest, or eggs. Mr. Gould, the author of the "Birds of Aus-

* "Trans. N.Z. Inst.," vol. x., art. xxv., p. 217.

tralia," conjectures that it may breed on the Mewstone and some other small islands to the south of Tasmania, from the fact that adult birds are commonly seen in the neighbourhood during the spring months; but up to the present time this supposition has not been verified. It will be interesting to ascertain whether the few specimens caught off our shores have come from a breeding-station to the south of New Zealand, or have wandered across from Tasmania.

Art. X.—*The Habits and Home of the Wandering Albatross* (Diomedea exulans).

By A. Reischek, F.L.S.

[Read before the Auckland Institute, 2nd July, 1888.]

This noble bird may justly be called the king among the sea-birds. Many times during my sea-voyages have I admired its flight and easy sailing over the waves, as it followed our vessel, hundreds of miles from the nearest land. Its power of flight surpasses that of most birds, and is easily accounted for by the unusual development of the muscles of the breast and wings, the latter being equal to, if not stronger than, those of the eagle. It is worthy of remark that the quills of the wing are spread or brought close together according as the bird is rising or falling in its flight. The steering is done not with the tail alone, but also with the broad webbed feet. These, when a straight course is being followed, are stretched out, and nearly concealed under the tail; but when a quick turn is required their position is altered, and the webs are spread in such a manner as to greatly assist the bird in turning. When there is little wind and the ocean is calm, albatrosses have great difficulty in rising from the water; when there is a swell they run along the water and rise with a wave. When alighting, on nearing the surface they bend the head back, curve the wings upwards, beating the air with numerous laboured strokes, then, straightening their feet, they let themselves fall. They are fast swimmers, but cannot dive. Their food, which consists chiefly of some of the lower forms of marine life found floating on the surface of the ocean, they scoop up with their bill in the same manner as the ducks.

I had long been anxious to visit their breeding-haunts, but had no opportunity of doing this until January, 1888, when I was afforded the privilege of accompanying the Government steamer "Stella" on her yearly cruise among the islands to the south of New Zealand. After visiting Stewart Island and the Snares, the steamer's course was directed towards the

Auckland Islands, and on the 25th January we anchored in Carnley Harbour. Having ascertained from Captain Fairchild that the vessel would not leave until the following evening, I at once prepared for an expedition to the hills, on which I was informed that albatrosses were then breeding; and at 4 o'clock in the morning the chief officer put me ashore. The first creatures I met were several sea-lions sleeping in the long grass, over which I almost fell. They gave discontented growls at being disturbed and driven from their lair, sitting up on their haunches and gazing at the intruder with their large eyes, showing their white canine teeth all the time. Moving onwards I had a dreadful scramble through dense low scrub interspersed with holes and swampy places, but at last I gained the hills above. My exertions caused me to suffer greatly, being far from well through overwork on the west coast of the South Island. After climbing over hills for about three miles I came to a slope where a colony of albatrosses had established a breeding-place. The birds were scattered about among the tussock-grass, sitting on their nests, and from their white plumage could be easily distinguished from the vegetation at a great distance. I found that their nests are always placed on sloping ground, and always on the most exposed side of the hill. They are composed of earth and grass cemented together, and are built in the form of a cone. They are usually about 2ft. in diameter and about 18in. high. Outside they are surrounded by a shallow drain, intended to carry off the surface-water. Within is placed a single egg. This is white, with a few brown spots on the broad end, and measures about 5·5in. in length by 3·1in. broad. In most cases I found the female on the nest, the male bird standing close to her, and occasionally feeding her. I noticed that sometimes the male relieved the female, but they never both leave the nest until the young one is able to defend itself against the skua gull (*Lestris parasiticus*). This rapacious bird devours every egg or nestling left unprotected. While taking the measurements of the first nest I came to I laid down the egg beside me, when a skua darted at it and destroyed it. They were so bold that they frequently came close enough for me to hit them with a stick.

On my approaching an albatross's nest the old bird seldom left it, but set up a croaking noise, clapping its mandibles together and biting at the intruder. After turning it off and taking away the egg, it returned and sat on the nest as before. The eggs were quite fresh on the 25th January, and good for eating when fried. There appears to be a difference in the time of laying at the different islands, for at Campbell Island, considerably to the south of the Auckland Islands, their eggs

were nearly all hatched by the end of January, while at Antipodes Island, a little to the north again, they had hardly begun to lay at the beginning of February. In all these three islands albatrosses are most plentiful.

The albatross takes five years to become fully mature, and in each year there is a slight change of plumage. The young, which are hatched in February, are covered with snow-white down, and a beautiful specimen in this stage exists in the Otago Museum. In the following December they lose their down, and the plumage is of a brown colour, with white under the wings and on the throat. In the second year the plumage is the same except that there is more white on the throat and abdomen. In the third year there is still more white, although mixed with blotches of brown, the under parts, however, being nearly all white. The wings and tail remain dark-brown. In the fourth year they very nearly acquire the full plumage. The male is white with a few very fine dark specks, except the wings, which are dark-brown. In the fifth year they reach their full growth, and the mature plumage is displayed—white, with blackish-brown wings. The measurements are as follows: Total length from the tip of the bill to the end of the tail, 3ft. 3in. Bill, 7in. Tail, 7·25in. Whole wing, from 4ft. 10in. to 5ft. 10in.; primaries, 1ft. 8in. Whole leg, 1ft. 10½in.; tarsus, 4·5in.; middle toe, 7in. The female is much smaller, as can be seen at once from the specimens exhibited.

Notwithstanding the ease and grace of the albatross on the ocean, on the land it is a most clumsy and helpless bird. Its walk is slow and waddling, like that of a duck, and it cannot take flight from a level piece of ground. It is for this reason that these birds have been gifted by nature with the instinct of making their nests on the slopes of mountains, for by running down-hill, and labouring hard with their wings, they can at last acquire momentum sufficient to raise themselves in the air. Once there they exhibit their true power, and are seen to the best advantage.

Art. XI.—*On a Specimen of the Brown Gannet* (Sula fusca) *shot in Napier Harbour, with Notes on other New Zealand Birds.*

By A. Hamilton.

[*Read before the Hawke's Bay Philosophical Institute, 9th July, 1888.*]

It is my good fortune to be able to record the occurrence of a bird which to the best of my belief has not yet been observed in New Zealand, although the remarkable part of the

matter is not the stranger's visit, but that it has not been recorded before this, for the Brown Gannet, or Booby *(Sula fusca)* has been obtained in nearly all the temperate regions of the globe, in many cases doubtless as a straggler; but now a specimen has been shot here in the bay, and is before you this evening very nicely preserved by Mr. Yuille. Mr. Smith, of the Masonic Hotel, has added the specimen to his collection, which is becoming extremely interesting and valuable. I have had considerable trouble in looking up any description of this species, which is common in the Atlantic, but at last found a good account in a work by Lathom, published in 1785, rather more than a hundred years ago. This I have transcribed, and have added a few particulars from other sources respecting the habits of the bird.

Lathom's "General Synopsis of Birds" (1785), Vol. iii., Pt. 2, p. 612.

Common Booby:—

Pelecanus Sula. Lin. Syst., 1, p. 218, 7.

Le Fou. Briss. Orn., vi., p. 495, 1; Buf. Ois., viii., p. 368, pl. 29.

Anseri Bassano congener fusca avis. Raii. Syn., p. 191, 6; Sloan, Jam., p. 322., t. 271, fig. 2.

Booby. Brown, Jam., p. 481; Catesby, Car. 1, pl. 87.

Description.—Size of the lesser gannet: length, 2ft. 6in. The bill nearly 4½in. long, toothed on the edges, and of a grey colour; base of it pale-brown; space round the eyes, and the chin, bare of feathers, and covered with a yellowish skin; irides pale-grey; the head, neck, upper parts of the body, wings and tail, cinereous-brown; the greater quills much the darkest; the tail brownish at the end, and in shape greatly cuneiform; the breast, belly, thighs, and vent white; legs pale-yellow; claws grey.

Catesby observes that these vary—some have white bellies, and others not—and that there is no perceivable difference between male and female. The young birds have the head and neck white, with a slight tinge of brown; but may be distinguished from having the feathers of those parts downy and soft, and not the usual texture.

Place.—Inhabits the Bahama Islands; and we believe likewise very common in many other parts of the world. One specimen came from Cayenne. It probably may be the sort mentioned by Dampier as being so plentiful in the Island of Aves, eight or nine leagues east of Buenos Ayres, which is described as a very simple creature, that will hardly go out of a man's way. These are said to build their nests on the ground in places where no trees grow, but make them on the last whenever they can be found. The flesh is black and fishy, yet is often eaten by the privateers. Is also met with in New Guinea.* This has been seen at Kamtschatka;† is found in the Faeroe Isles; and has also been met with on our own coasts [England] a few years since.‡

The term "booby" is applied by navigators more particularly to the Brown Gannet *(Sula fusca)*, which inhabits the desolate islands and coasts where the climate is warm, or even temperate, throughout the greater part of the globe. The ap-

* Bosman. "A New Description of the Coast of Guinea." 1721.
† Ellis., Nar., ii., p. 189.
‡ "Arctic Zoology," by Thos. Pennant. 1784.

parent stupidity of the boobies is proverbial: calmly waiting to be knocked on the head as they sit on shore, or perching on the yard of a ship till the sailor climbs to their resting-place and takes them off with his hand, they fall a prey to the most artless birdcatcher. Even Byron's shipwrecked wretches, though—

> Stagnant on the sea,
> They lay like carcasses,

"caught two boobies and a noddy;" and the incident actually did occur in Bligh's celebrated voyage consequent on the mutiny on board the "Bounty," when he and his boat's crew were in a most deplorable state. "Monday, the 25th," says Bligh, "at noon, some noddies came so near to us that one of them was caught by hand. . . . In the evening, several boobies flying very near to us, we had the good fortune to catch one of them. . . . I directed the bird to be killed for supper, and the blood to be given to three of the people who were most distressed for food; the body, beak, and feet I divided into eighteen shares. . . . Tuesday, 26th, we caught another booby; so that Providence appeared to be relieving our wants in a most extraordinary manner. The people were overjoyed at this addition to their dinner, which was distributed in the same manner as on the preceding evening, giving the blood to those who were the most in want of food."

Dampier says that on the Alcranes Islands (Alacranes), on the coast of Yucatan, the crowds of these birds were so great that he could not pass their haunts without being incommoded by their pecking. He observed that they were arranged in pairs, and conjectured that they were male and female. He succeeded in making some fly away by the blows he bestowed on them, but the greater part remained in spite of his efforts to compel them to take flight.

De Gennes, in his voyage to the Straits of Maghellan, says that in the Island of Ascension there were such quantities of boobies that the sailors killed five or six at a time with one blow of a stick.

The Vicomte de Querhoent says that the French soldiers killed an immense quantity on this same island, and that their loud cries when disturbed at night were quite overpowering.

This apparent exception to the general rule of self-preserving instinct is so remarkable that we are led to look for some cause, and perhaps this may be found in the structure of the animal; for, according to many writers whose veracity cannot be doubted, the boobies stay to be taken and killed after they have become familiar with the effect produced by the blows or shots of their persecutors.

In the case of most animals which, from not knowing his power, have suffered man to approach them to their destruction, alarm has been soon taken, the idea of danger has been speedily associated with his appearance, and safety has been sought in flight; but the wings of the booby are so long and its legs so short that, when once at rest on level ground, the bird has great difficulty in bringing the former into action, and when so surprised it has no resource but to put on a show of resistance with its beak, which is, to be sure, generally despised by its persecutor.

In the cases recorded by Bligh the birds were probably fatigued by wandering too far from the rocky shores which are their ordinary haunts. There they are generally to be seen constantly on the wing over the waves which beat at the foot of the crags, intent on fishing.

Though so well furnished with oars they are said to swim but seldom or never to dive. Their mode of taking their prey is by dashing down from on high with unerring aim upon those fishes which frequent the surface, and instantly rising again in the air. They walk with difficulty, and when at rest on land their attitude is nearly vertical, and they lean on the stiff feathers of the tail, like the cormorants, as a third point of support. The ledges of rocks or cliffs covered with herbage are the places generally selected for the nest, and there in great companies they lay their eggs, each hen bird laying from two to three. The young birds for some days after hatching are covered with a down so long and thick that they resemble powder-puffs made of swan's down.

The boobies seldom wander more than twenty leagues from land, to which they usually return every evening; and their appearance is considered by mariners as a sure token of their vicinity to some island or coast.

The colour of the *Sula fusca*, or Brown Booby, is blackish-brown or ashy-brown above and whitish beneath; the primaries are black, and the naked skin about the head is reddish; the orbits and base of the bill are yellow, and the point of the bill is brown; the legs are of a straw-colour. In length the brown booby is about 2ft. 5in, the bill measures 4½in. or thereabout, and the tail 10in. The young birds are spotted with white and brown.

It is almost impossible to open the pages of the old voyagers who have fallen in with these boobies without finding some accounts of the constant persecution to which the latter are subjected by the frigate or man-of-war birds.

Lesson, indeed, doubts this. He says, "The boobies have been so named because it has been supposed that the frigates compel them to disgorge the fish which they had taken; but this appears to me to be erroneous. The booby is

warlike, he lives fearlessly near the frigate, and swallows the fish which he has captured in peace."

Cuvier, Buffon, and Temminck, on the contrary, give credence to the narratives of the frigate's persecution, and, indeed, it is difficult to believe that so many eye-witnesses should be mistaken.

Feuillée says, "I have had the pleasure of seeing the frigates give chase to the boobies. When they return in bands in the evening from their fishing the frigates are in waiting, and, dashing upon them, compel them all to cry for succour, as it were, and in crying to disgorge some of the fish they are carrying to their young ones. Thus do the frigates profit by the fishing of the boobies, which they then leave to pursue their way home."

Legnat, in his Voyage, writes thus: "The boobies come to repose at night upon the Island Rodriguez, and the frigates, which are huge birds, so called from their lightness and speed in sailing through the air, wait for the boobies every evening on the tops of the trees. They rise, on the approach of the latter, very high in the air, and dash down upon them like a falcon on his prey, not to kill them, but to make them disgorge. The booby struck in this manner by the frigate gives up his fish, which the frigate catches in the air. The booby often shrieks, and shows his unwillingness to abandon his prey; but the frigate mocks at his cries, and, rising, dashes down upon him anew till he has compelled the booby to obey."

William Dampier observes that he remarked that the man-of-war birds and the boobies always left sentinels near their young ones, especially while the old birds were gone to sea on their fishing-expeditions, and that there were a great number of sick or crippled man-of-war birds which appeared to be no longer in a state to go out for provisions. They dwelt not with the rest of their species, and, whether they were excluded from their society or had separated themselves voluntarily, they were dispersed in various places, waiting apparently for an opportunity of pillage. He adds that one day he saw more than twenty on one of the islands (the Alcranes), which from time to time made sorties to procure booty. The man-of-war bird that surprised a young booby without its guard gave it a great peck upon the back to make it disgorge—which it instantly did—a fish or two as big as one's wrist, which the old man-of-war bird quickly swallowed. He further speaks of the persecution of the parent boobies by the able-bodied frigate-bird, and says that he himself saw a frigate fly right against a booby, and with one blow of its bill make the booby give up a fish just swallowed, upon which the frigate darted with such celerity that he seized it before it reached the water.

Catesby and others mention seeing similar encounters.

Nuttall says, "The boobies have a domestic enemy more steady though less sanguine in his persecutions than man: this is the frigate pelican, who, with a keen eye descrying his humble vassal at a distance, pursues him without intermission, and obliges him by blows with his wings and bill to surrender his finny prey, which the pirate instantly seizes and swallows."

The booby utters a loud cry, something between that of the raven and the goose; and this is heard more particularly when they are pursued or when, assembled together, they are seized with a sudden panic. Their nests, according to Dampier, are built in trees in the Isle of Aves, though they have been observed in other places to nestle on the ground. They always associate in numbers on the same spot, and lay one or two eggs. The young are covered with a very soft down. Nuttall says that they abound on the rocky islets off the coast of Cayenne and along the shores of New Spain and Carraccas, as well as in Brazil and the Bahamas, where they are said to breed almost every month in the year. In summer they are not uncommon on the coast of the Southern States of North America. The flesh he describes as black and unsavoury.

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2. *Ardea novæ-hollandiæ.*

The White-fronted Heron.—This species is not nearly so common as the Common Blue Heron (*Ardea sacra*), and I have not seen a specimen for many years; but the one now before you was killed at Waipawa in May last. It is now in the collection of Mr. Smith, of the Masonic Hotel in this town.

3. *Anthornis melanura.*

The Bell-bird has almost disappeared from Hawke's Bay and the Seventy-mile Bush for some years. The specimen before you was procured at Takapau, and the sender informs me that they are once more appearing in that district.

4. *Eudynamis.*

Amongst a collection of New Zealand bird-skins sent to the Museum I found a skin of what appeared to be *Eudynamis* with the long tail-feathers imperfect, some not fully grown. On taking up the bird to ticket it, I saw that the breast, instead of the usual brown marks, was distinctly transversely barred with black metallic bars, as in the Bronze Cuckoo (*Chrysococcyx*). These bars extend from the beak to the vent. The bill is less robust than *Eudynamis*. The feet are light in colour, like those of an albino specimen. It has certainly the character of *Eudynamis* when seen from the back; but from the under side it suggests a cross between *Eudynamis* and *Chrysococcyx*.

5. *Ocydromus* (albino).

We have in the Museum a beautiful specimen of a *weka*, snow-white with the exception of a few feathers on the back and at the base of the tail: these are of the usual colour. The legs were of a light-pink or flesh-colour, and much thinner in proportion than in ordinary. Caught at Mohaka.

6. *Carpophaga novæ-zealandiæ* (albino).

A curious variety of the New Zealand Pigeon was sent to me by Mr. Harding from Castle Point. The plumage is of a dirty-white colour, many of the feathers on the neck and shoulders being tipped irregularly with a ferruginous-brown colour.

Art. XII.—*On new Species of* Araneidea.

By A. T. Urquhart.

[*Read before the Auckland Institute, 22nd October, 1888.*]

Fam. THERIDIIDÆ.

Genus **Linyphia**, Latr.

Linyphia purpura-punctata, sp. nov.

Male.—Ceph. th., long, 1·2; broad, 1. Abd., long, 1·8; broad, 1·2. Legs, 1, 2, 4, 3 = 6·8, 5, 4, 2·7 mm.

Cephalothorax yellow-brown, olive-brown dorsal band bifurcates from base of caput, connecting posterior central and lateral eyes; rugulose; oval, slightly compressed forwards; pars cephalica moderately convex, roundly truncated; thoracic fovea somewhat oval, caput and radial striæ moderately defined; profile-contour rises at an angle of about 35° from thoracic junction, somewhat horizontal across pars cephalica, dips forwards from posterior row of eyes; *clypeus* vertical, height nearly equals diameter of a fore-lateral eye.

Eyes on black spots; posterior row moderately recurved, central pair separated from each other by a space equal to rather more than their diameter, rather less than that interval from side-eyes next to them, two-thirds their space from anterior-centrals; fore-row recurved, median pair, smallest of eight, their diameter from each other, less than their radius from side-eyes; interval between lateral eyes rather exceeds interspace between posterior-centrals; seated obliquely on low eminences.

Legs yellowish, faint annulations on tibiæ and metatarsi; fairly stout; black hairs, long spines, on femoral, genual, tibial, and metatarsal joints, except metatarsi of 1–2.

Palpi, humeral, cubital, and radial joints pale straw-colour,

former article one-third longer than two latter together; cubital joint somewhat linear, radial rather shorter than cubital, viewed from above somewhat cup-shaped; digital joint large, globose; springing from near articulation of joint is a brownish, irregular, triangular, semi-detached process, at extremity nearly as broad as long, fore-angles prolonged into two apophyses, outer black-brown, stout, pointed; inner longest, membranous, lake-brown, concave within; side-face of bulb spiral, glossy, outer circle broad, pale; inner circle red-mahogany; beneath the dark-brown, membranous, free apex is a black, pointed process; lamina bulbi broad-ovate, placed rather beneath bulbus, hairs rather sparse.

Falces brownish-yellow; conical, project moderately at base in front, directed rather forwards, exceed humeral joint of palpus in length.

Maxillæ yellowish-brown; fore-part broad, rounded, inclined towards *labium*, which is dark chocolate-brown; oval one-third broader than long, strongly everted.

Sternum cordate; yellow-brown, dark margin.

Abdomen oviform; ground-colour umber-brown, series of pinkish, purple-tinted flecks on either side of dorsal band, which is less defined than females, dark-brown near spinners; ventral surface brownish.

Female.—Ceph. th., long, 1; broad, 1. Abd., long, 2·1; broad, 1·8. Legs, 1, 2, 4, 3 = 6·5, 5, 4, 3 mm.

Cephalothorax yellowish-brown, dorsal band and marginal zone olive-brown, former commences at thoracic fovea, bifurcating above junction of caput, to posterior eyes; glabrous; oval, moderately compressed forwards; pars cephalica convex, rounded, lateral index about equal to space between a hind-lateral eye and the hind-central furthest from it; fovea somewhat oval, caput groove and radial striæ moderately defined; profile-line rises slightly across ocular area, somewhat level to limit of caput, slopes moderately to base; *clypeus* vertical, height rather exceeds diameter of a fore-lateral eye.

Eyes on black eminences, laterals most prominent; posterior row moderately recurved, of about equal size, nearly equidistant, central eyes separated by an interval equal to their diameter and a quarter, about one-third less than their space from fore-centrals; anterior row recurved, median pair about one-third size of laterals, scarcely their breadth apart, about that interval from side-eyes; interspace between laterals rather exceeds that between posterior median pair.

Legs shade lighter than cephalothorax, rather faint annulations on tibiæ and metatarsi; moderately slender; black hairs, long, slender spines.

Palpi pale yellow-brown; slender, about length of cephalothorax; armature, hairs, and bristles.

Falces and cephalothorax concolorous; conical, directed rather forwards, project somewhat in front at base; fangs small, reddish-brown.

Maxillæ, fore-half broad, convex, rounded, moderately inclined towards labium, yellow-brown. *Lip* one-third broader than long, recurved; chocolate-brown, margin pale.

Sternum yellowish-brown; cordate.

Abdomen oviform; umber-brown, flecked with large and small pinkish, purple-tinted, somewhat metallic spots; dorsal band brown, sinuate margins, posterior two-thirds narrower and darker; lateral margins dark-brown, few purple streaks and flecks; ventral surface displays a brown purple-margined, shield-shaped mark; abdomen sparsely clothed with short blackish hairs. *Corpus vulvæ* chestnut-brown; moderately prominent; represents a transverse area divided by a glossy, brown, rather narrow, x-shaped septum, whose base is prolonged, horizontally, on the tumid margins of foveæ.

Several specimens, Wairongomai Gorge, *A. T. U.*

Linyphia nitidulum, sp. nov.

Female.—Ceph. th., long, 1·6; broad, 1. Abd., long, 2; broad, 1·8. Legs, 1, 2, 4, 3 = 5·9, 4·9, 4·2, 2·2 mm.

Cephalothorax brownish-yellow, median band and marginal zone dark-olive; former broad, bifurcates forwards from base of caput; areolate; oval, moderately compressed forwards, pars cephalica somewhat depressed, roundly truncated; lateral index equal to space from a hind-lateral eye to the hind-central furthest from it; thoracic indentation not clearly defined, caput and radial striæ well marked; contour of profile rises slightly across pars cephalica to hind row of eyes, dips somewhat abruptly backwards; depth of *clypeus* equals diameter of a fore-lateral eye, directed sensibly inwards.

Eyes on black spots, anterior and posterior rows recurved, latter moderately; hind row about equidistant, central pair scarcely their breadth apart, more than twice their diameter from fore-centrals, which are about their breadth from each other and side-eyes next to them; lateral eyes sensibly larger than posterior-centrals, more than one-third larger than fore-median pair; seated obliquely, their diameter and a half from one another, on tubercular eminences, fore-pair strong.

Legs and cephalothorax concolorous, femora faintly clouded, tibiæ and metatarsi annulated with an olive tint; slender; armature, few black hairs and bristle-like spines.

Palpi colour of legs, moderately strong.

Falces light amber-colour; somewhat conical, directed visibly inwards.

Maxillæ brownish-yellow; basal half longitudinally indented; fore-end rounded, tumid; inclined outwards; strong fringe of hairs. *Labium* chocolate-brown; oval, more than twice as broad as long, everted; about one-fourth as long as maxillæ.

Sternum brownish-yellow, margins clouded; coarse black hairs; cordate; slight eminences opposite coxæ.

Abdomen ovoid, fore-end pointed, projects over base of cephalothorax, lateral margins longitudinally corrugated; dorsal field creamy-brown, flecks of a paler hue; median mark broad, yellow margins, irregularly acutely crenate, extends from base to spinners, fore-half numerous pale flecks, few brown, somewhat angular marks on margin; posterior half maroon-colour; sides brownish, longitudinally streaked with dark olive-brown, margins yellow. Ventral surface brownish-yellow; displays a somewhat ovate, olive-coloured mark, two yellow spots. *Corpus vulvæ* amber-colour, speckled, glossy, somewhat oval, moderately prominent, transverse eminence, centrally produced into a longitudinal costa, at base of latter is a shallow, cuneate depression, with lake-coloured margins; fore-part concave within and prolonged above into a short, rather broad septum, which loops up a long, narrow, transverse membrane, projecting outwards above the rima genitalis; septum and membrane have glossy-brown, beaded margins.

This rather handsome specimen was captured amongst the light bush on the summit of Te Aroha. *A. T. U.*

Linyphia rufo-lineata, sp. nov.

Male.—Ceph. th., long, 2·8; broad, 2. Abd., long, 3·2; broad, 2. Legs, 1, 2, 4, 3 = 21, 13·1, 9, 7 mm.

Cephalothorax light yellow-brown; on posterior slope of pars cephalica is an olive-brown, lanceolate mark, which bifurcates forwards to posterior-lateral eyes; lateral margin of caput displays a longitudinal streak of similar hue; almost glabrous; rugulose; oval; moderately compressed forwards; caput moderately convex, lateral index nearly equals breadth at posterior row of eyes; median indentation on pars thoracica longitudinal, deep; caput and radial striæ well-defined; profile-contour represents a moderate double arch; *clypeus* vertical, height equal to more than diameter of a fore-central eye.

Eyes large, of almost equal size; posterior row procurved, centrals visibly the largest of eight, placed on black oval spots, three-fourths their diameter apart, separated by an interval equal to one-third their breadth from side-eyes next to them; anterior row recurved, median pair seated on a moderate black eminence, three-fourths their diameter from each other,

their breadth and a quarter from hind-centrals; separated by a space equal to one-fourth their diameter from side-eyes; laterals seated obliquely, close together, on separate, black, tubercular eminences.

Legs and cephalothorax concolorous; red-chestnut annuli on all joints; light hairs; long, slender spines on femoral, genual, tibial, and metatarsal joints.

Palpi colour of legs; long; humeral joint rather exceeds cubital and radial in length; cubital joint about one-fourth shorter than radial, fore-third angular, furnished with a long bristle; fore-third of radial joint sharply constricted, margin tumid, brownish; projects two long, moderately-strong bristles; clava large; projecting from beneath the lip-like margin of the radial joint is a large yellow-brown, hairy process, terminal half compressed, somewhat quadrilateral, margin blackish; above latter process a long, stout, tapering, amber-coloured apophysis, furnished with short hairs, projects forwards from beneath a black-brown, acute-crenate, membranous fringe; projecting upwards and outwards from between the two latter organs is a short, stout, curved, pale amber-coloured process, concave beneath; bulbus genitalis somewhat spiral, apex membranous, broad, linear, rounded, concave, reddish-brown; projecting outwards at a right angle from base of contracted apex is a broad, acutely-pointed, reddish, membranous process; projecting from within concavity at bulbus are two stout, glossy-black apophyses; base of outer one broad, depressed in centre, fore-part compressed and rounded; lamina bulbi beneath bulb, apex pointed; moderately hairy.

Falces light mahogany-brown; transversely rugose; vertical; fore-third remarkably concave on outer side; equal in length to humeral joint of palpus.

Maxillæ broadest and slightly rounded at extremity; moderately inclined towards each other; brownish-yellow, base suffused with brown. *Labium* somewhat oval, short, everted; base chocolate-brown, margin yellowish.

Sternum brownish; somewhat cordate; eminences opposite coxæ.

Abdomen oviform, indentation above pedicel; yellowish-olive, numerous yellowish flecks; folium ovate, base dark-olive; a pale ⊥-shaped mark extends backwards from cleft; nearly in centre of abdomen are two closely-connected, somewhat oval, creamy-white transverse marks; margins red, less pronounced on posterior side, with an outer border of dark olive-brown; prolonged margins terminate with white spots; between oval marks and basal ⊥-shaped mark are two whitish sinuating lines; on posterior half of dorsal line is a not-well-defined, yellow-flecked, tapering streak, bifurcating forwards

to oval marks; between latter marks and spinners are a series of three transverse, oblique, more or less pronounced, dark bars, fore-pair terminate with a white spot. Ventral surface yellowish; shield brown.

Female.—Ceph. th., long, 2·8; broad, 2. Abd., long, 4; broad, 3·2. Legs, 1, 2, 4, 3=14, 10, 8, 6 mm.

Cephalothorax brownish-yellow; dorsal mark olive-brown; somewhat fan-shaped on base of pars cephalica, compressed across pars thoracica; rugulose; almost glabrous; oval, moderately compressed forwards, lateral index exceeds breadth of eye-area; normal grooves fairly marked, fovea deep, somewhat circular; profile-line represents a moderate double arch; *clypeus* in height rather exceeds diameter and a half of a fore-central eye.

Posterior row of *eyes* procurved, sensibly exceed fore-row in size; centrals on black, oval spots, separated by an interval scarcely equal to their diameter, half that space from laterals next to them, their breadth and a half from fore-centrals; anterior row recurved; median pair seated on slight prominences, interspace rather exceeds their breadth, separated by scarcely their diameter from side-eyes; laterals seated obliquely, one-fourth their breadth apart, on dark, tubercular eminences.

Legs brownish-yellow, more or less defined brown annulations; slender; yellowish hairs, spine armature similar to males; superior tarsal claws — 1st pair, slightly curved, 14 close teeth, increasing a little in length; inferior claw long, 2 teeth.

Palpi resemble legs in colour and armature; length 4mm. Palpal claw moderately curved, long, 7 teeth.

Falces yellowish, glossy; vertical, conical, tumid and projecting forwards at base.

Maxillæ rather longer than broad, apex wide, slightly rounded; yellowish. *Labium* less than one-half length of maxillæ, somewhat oval, broader than long, everted; olive-brown.

Sternum cordate; eminences opposite coxæ; yellow-brown, margin brownish.

Abdomen oviform, projects moderately over base of cephalothorax; light stone-colour; folium sinuate, olive-brown, stone-coloured flecks; on fore-third are a series of undulating angular marks—apices directed forwards, of a light stone-colour, except the largest and posterior one, which has a creamy-white hue, anterior margin reddish-pink; from the latter mark a narrow subulate light stone-coloured mark extends half-way to spinners; on dorsal line, intersecting the pattern, is an olive-brown streak, which takes a hastate form on the creamy angular bar; a series of brownish oblique broad

streaks, interrupted by median pattern, extend length of folium; lateral margin yellowish-olive, white next to folium, flecks yellowish; on ventral surface is a semi-oval olive-brown mark, margined with light flecks; spinners short; light mahogany-brown. *Vulva* amber-colour, one-third broader than long, transversely rugose, projects over rima genitalis; displays two circular, moderately deep, brownish foveæ, divided by a slightly-elevated septum, whose breadth perceptibly exceeds their diameter, and nearly equals width of outer margin; facing septum is a somewhat concave depression, equalling it in breadth; margins of *corpus vulvæ* terminate, on either side of concavity, in slight, somewhat conical, brown eminences.

Several examples, summit of Te Aroha, *A. T. U.*

Linyphia nemoralis, sp. nov.

Female.—Ceph. th., long, 1. Abd., long, 1·5. Legs, 1, 2, 4, 3 = 7·4, 4, 3, 2·5 mm.

Cephalothorax dark olive-brown, suffused with black-brown; rugose; ovate lateral marginal compression at pars cephalica very slight; caput convex, viewed from front broad ovate; indentation below eyes; thoracic fovea longitudinal, normal grooves slight; profile-contour nearly semicircular, crown of arch at limit of caput; *clypeus* convex, projects moderately forwards, height equals about two-thirds depth of ocular area.

Eyes of tolerable and nearly equal size; posterior row procurved, median-pair three-fourths their diameter from each other, separated by scarcely twice that interval from side-eyes; anterior row recurved; centrals dark, smallest of eight, seated on a prominence, their radius apart, further from laterals of same row than they are from posterior median pair; form a trapezoid with hind-centrals, longer than broad; lateral eyes have the pearl-grey lustre of posterior-centrals, placed obliquely on dark, moderately prominent eminences, contiguous.

Legs brownish-yellow, rather faint-brown annulations, most pronounced on 3–4; in some examples, except base of femora, 1–2 have a reddish tinge, with little or no trace of annuli; slender; fine hairs, few bristle-like spines on genual and tibial joints.

Palpi straw-colour, except digital joint which has a brownish hue; latter article rather longer than humeral, more than twice length of pars radialis; no claw; black hairs.

Falces brownish-yellow, basal half suffused with reddish-brown; stout, length exceeds digital joint of palpus by one-fourth, project forwards at base, directed outwards, superior margin somewhat concave at extremity; outer row of teeth strong, two central longest; fangs long.

Maxillæ yellowish, basal half suffused with chocolate-

brown; linear-oval, curve over *labium*, which is somewhat oval, rather broader than long, everted, more than half length of maxillæ; chocolate-brown, apex pale.

Sternum dark chocolate-brown; covered with small papillæ; cordate, nearly as broad as long.

Abdomen oviform, profile-line represents a semicircle, rising abruptly from base of cephalothorax; stone-colour; folium terminates a little above spinners, its dark-brown, coarse, irregular, somewhat acute-crenate margins enclose a stone-coloured leaf-like space, which has in some examples two angular brown bars on posterior half, apices directed forwards; fore-part of pale area and margins of folium widen out on base; ventral surface brown, margin dark. *Corpus vulvæ* moderately tumid, inferior (anterior) margin prolonged into a short, broad scape, fore-end circular, concave on upper side; superior margin curves inwards, forming a short septum, beneath the scapus vulvæ, which intersects two ovate foveæ; beneath the superior tumid margin is a narrow, transverse, lip-like projection.

Male.—Ceph. th., long, 1. Abd., long, 1. Legs, 1, 2, 4, 3 = 8, 5, 3·5, 3 mm.

Cephalothorax mahogany-brown; rugose; oval, lateral marginal constrictions at caput slight, contour of profile resembles female's; height of *clypeus* rather less than one-half depth of facial space.

Eyes, posterior row procurved, central pair their radius apart, rather more than their diameter from laterals; anterior row recurved, median pair placed on a dark, moderate prominence, separated by an interval equal to one-third of an eye's diameter, scarcely their breadth and a half from posterior-centrals, visibly more than their diameter from side-eyes of same row; laterals seated obliquely on moderate tubercular eminences, nearly contiguous.

Legs reddish-brown, except basal half of femora and coxæ, which have a dull straw-colour; 3–4 brown annuli at articulations of tibiæ and fore-end of metatarsi; armature, sparse, fine hairs; one long bristle-like spine on genual, two on tibial joints.

Palpi pale straw-colour; humeral joint about one-fourth longer than cubital and radial together; cubital joint rather narrow at base, slightly exceeds penultimate article in length; latter joint cyathiform, furnished with black bristles; pars digitalis reddish-brown; large, globose; laminæ moderately hairy, directed towards each other, circular, convex, project in front, a dark, stout, curved process, directed forwards and downwards; laminæ indented beneath processes, display above, on outer side, a remarkable lunulate indentation; bulbus genitalis complex, viewed laterally, circular, some-

what (plane) spiral, rugose; margin black-brown, bulbus yellowish, circular margins reddish-brown; near centre of the somewhat depressed lobe are two yellowish, short, tooth-like processes, directed downwards; beneath them the dark, membranous margin is produced into a long, fine, black apophysis, curving forwards and upwards, central third ciliate.

Falces reddish-brown, basal half suffused with olive-brown, somewhat conical, directed visibly forwards, terminal half outwards.

Maxillæ brownish-yellow, base suffused with olive-brown; linear-oval curve over *labium;* latter oval, chocolate-brown.

Sternum dark chocolate-brown; cordate.

Abdomen oviform; stone-colour; folium nearly length of dorsal line; black-brown, coarse, acute-crenate margins enclose a stone-coloured leaf-like space. Ventral surface brownish.

Three specimens taken on the summit of Te Aroha, *A. T. U.*

Genus **Theridium**, Walck.

Theridium brunnea-folium, sp. nov.

Female.—Ceph. th., long, 2; broad, 1·2. Abd., long, 3; broad, 2·5. Legs, 1, 4, 2, 3 = 10·5, 8, 6·5, 5 mm.

Cephalothorax pale-brown, whitish radial streaks; caput, broad median band, and lateral margins suffused with brown; areolate; glabrous; oval, moderately compressed forwards, pars cephalica rather depressed, lateral index about equal to space at hind-central eyes; fovea large, deep, somewhat circular; radial striæ and caput-grooves moderately defined; contour of profile arched, dips slightly at median indentation; *clypeus* projects forwards, height visibly exceeds depth of ocular area.

Posterior row of *eyes* procurved; median pair—which are sensibly the largest of eight—separated by rather more than their diameter; interval between them and laterals exceeds latter space by one-third; anterior row recurved; central eyes slightly further from one another than they are from posterior median pair, with which they nearly form a square, anterior side widest; centrals rather less than their breadth from side-eyes; laterals placed obliquely on dark tubercular eminences, nearly contiguous.

Legs brownish-yellow, reddish-brown annulations on tibial and metatarsal joints; armature sparse, dark hairs, slender bristles.

Palpi yellowish, radial and digital joints reddish; length of cephalothorax.

Falces glossy, amber-colour; somewhat linear, directed slightly forwards, equal to pars digitalis of palpus in length.

Maxillæ yellowish; long, somewhat acutely pointed, inclined over *labium*, which has an olive tinge; somewhat semicircular, nearly as long as broad, about one-half length of maxillæ.

Sternum yellowish, dark margins; cordate; areolate; slight eminences opposite coxæ.

Abdomen oviform, peduncle rather exposed; folium covers dorsal surface, runcinate, well-defined; light chocolate-brown, pale flecks, margins picked out with dark-brown; median band creamy-white; narrow, throws off few short transverse bars, fore-third lanceolate; lateral margins and ventral surface creamy-brown, numerous pale flecks; few brownish, transverse, somewhat ill-defined bars beneath; spinners short, brown. *Vulva* dark-brown; projects over rima genitalis, somewhat oval concavity above, fore-margin of latter tumid, notched.

Single specimen, summit of Te Aroha, *A. T. U.*

Theridium niger-punctillum, sp. nov.

Female.—Ceph. th., long, 2; broad, 1·5. Abd., long, 3; broad, 2·7. Legs, 1, 4, 2, 3 = 11, 8·2, 6·8, 4·8 mm.

Cephalothorax pale reddish-brown, caput and median band lightly clouded with olive; areolate; oval, laterally constricted forwards; pars cephalica moderately convex, lateral index equal to space from a hind-lateral eye to hind-central next to it; thoracic fovea circular, deep; normal grooves rather faint; profile-contour rises a little from occiput, represents a low arch across pars thoracica; *clypeus* directed perceptibly forwards, height equal to depth of eye-area.

Eyes tolerably small, do not differ much in size; posterior row procurved, median pair largest of eight, sensibly less than their diameter from each other, rather more than that space from side-eyes; anterior row recurved, centrals further from one another than they are from hind pair, with which they nearly form a square; lateral eyes have the pearl-grey lustre of posterior-centrals, placed obliquely on dark, moderately prominent, tubercular eminences, contiguous.

Legs yellowish, red-brown annulations at articulation of joints; femora of one pair speckled; long, slender; hairs and bristles sparse.

Palpi yellowish, hairs sparse, bristle on cubital joint; length, 2mm.

Falces yellowish, reddish about apex; linear, vertical.

Maxillæ pale, dull, brownish-yellow; stout, spathulate, inclined towards *labium*, which is semicircular, less than half length of maxillæ; slightly everted; orange-brown.

Sternum colour of legs; areolate; cordate.

Abdomen oviform, very convex above, pointed at spinners, moderately so at base; pale, olive-tinted stone-colour, thickly

spotted with creamy-white flecks, oblique streaks of normal hue, remarkable irregular black mark between second and last oblique streaks; hairs short, light, sparse. *Vulva* glossy, reddish-black; represents two somewhat circular connected projections; on upper surface are two foveæ, intersected by a longitudinal groove; reddish-brown fan-shaped marks radiate from each concavity.

Single specimen captured at the base of Te Aroha, *A. T. U.*

Theridium porphyreticum, sp. nov.

Female.—Ceph. th., long, 2; broad, 1·5. Abd., long, 3; broad, 2. Legs, 1, 2, 4, 3 = 9, 6, 5·4, 4 mm.

Cephalothorax pale, brownish straw-colour; areolate; oval, slightly compressed forwards; pars cephalica moderately convex; lateral index equal to space from a fore-lateral eye to the hind-central next to it; thoracic fovea somewhat oval, normal grooves deep; contour of profile represents a moderate arch; *clypeus* nearly vertical, height scarcely equals depth of eye-area.

Posterior row of *eyes* sensibly procurved, median pair ovate, pearl-grey, black margins, separated by an interval perceptibly exceeding their breadth, their diameter and a half from laterals next to them; anterior row recurved, centrals brownish, placed on moderate black eminences, nearly form a square with posterior pair; lateral eyes have the brownish hue of fore-centrals, seated obliquely on black tubercular eminences, contiguous.

Legs and cephalothorax concolorous; moderately slender; armature very sparse.

Palpi colour and armature of legs.

Falces brownish straw-colour; vertical, somewhat linear and aplanate, double row of small teeth.

Maxillæ long, roundly truncated on superior side, single row of short bristles on margins, inclined towards *labium*, which is about as long as broad, rounded; organs pale-brown.

Sternum yellowish, cordate.

Abdomen oviform, basal end rather the widest and most pointed; dorsal field—except base, which is light-brown—clouded with black-brown, has a pinkish tint graduating into a pale yellow-brown, thickly flecked with a lighter hue, about marginal zone and ventral surface; posterior three-fourths of dorsal field clouded with reddish-purple, deepening in shades towards spinners; on median line are two creamy-white marks; basal lanceolate, forms a disconnected petiole to the doubly serrate leaf-shaped posterior mark, which extends to spinners; across the constriction, below the central im-

pressed spots, is a dash of red. The abdomen in the vicinity of the vulva had shrunk somewhat when the specimen was described. Branchial opercula long, linear; pale-lemon colour. *Corpus vulvæ* moderately prominent; above the rima genitalis is a large circular orifice.

Single example, Wairongomai Gorge, *A. T. U.*

Theridium gracilipes, sp. nov.

Female.—Ceph. th., long, 1·1; broad, 1. Abd., long, 2; broad, 1·6. Legs, 1, 4, 2, 3 = 11·5, 7·5, 7·3, 6 mm.

Cephalothorax light-brown clouded with olive-brown, except fore-part of pars cephalica and lanceolate median streak; areolate; ovate, base broad; caput moderately convex, roundly truncated; eminence of fore-central eyes projects a little forwards; thoracic indentation somewhat triangular, normal grooves fairly defined; contour of profile represents a low arch; *clypeus* directed forwards, height nearly equals depth of ocular area.

Fore and hind row of *eyes* recurved, curvature of posterior row nearly equals that of anterior; eyes of hind row of equal size, centrals are separated from one another by an interval equal to their diameter, and from laterals by about their radius; anterior-centrals dark, seated on a moderate blackish prominence, less than their diameter apart, about one-third smaller than hind-median pair, with which they form a trapezoid, whose posterior side is widest; lateral eyes have the pearly lustre of posterior-centrals, placed obliquely on strong, dark-lake rings, nearly contiguous.

Legs yellow-brown; short, stiff hairs, apparently no bristles; long, slender.

Palpi resemble legs in colour; dark hairs, fine bristle on cubital and radial joints; slender.

Falces yellowish; vertical, somewhat conical, fore-third directed outwards.

Maxillæ yellowish-brown; spathulate, inclined towards *labium*, which is semicircular, margins very tumid; yellowish-brown, base dark.

Sternum, yellow-brown, margins olive-brown; cordate, numerous small mammiform eminences.

Abdomen, profile oviform, posterior end obtuse, viewed from above pointed somewhat sharply at either extremity; integument olive-brown, posterior end dark, on dorsal field and lateral margins are about 15 irregularly-shaped light stone-coloured patches; ventral surface olive-brown; hairs short, sparse. *Corpus vulvæ* moderately prominent, dark amber-colour; within a rather large circular area, defined by a narrow membrane, are three moderately prominent lobes enclosing a cordate space, apex directed towards spinners,

rather exceeding the upper and largest lobe in size; lateral lobes mussel-shaped, superior reniform.

Single specimen, colour affected by spirit. Te Aroha, *A. T. U.*

Fam. EPEIRIDÆ.

Genus **Epeira**, Walck.

Epeira dumicola, sp. nov.

Female.—Ceph. th., long, 2·5; broad, 2·2; facial index, 1. Abd., long, 5·2; broad, 4·2. Legs, 1, 2, 4, 3 = 8·7, 8·1, 7·5, 4·5 mm.

Cephalothorax dull raw-sienna; few pale hairs on pars thoracica; clathrate; length equals that of the genual and tibial joints of a leg of 4th pair; sides well-rounded, lateral constrictions at caput tolerably sharp; pars cephalica convex, ocular eminence rather low, lateral index equals space between posterior-lateral eyes; thoracic indentation and radial striæ not well-defined, caput-grooves more pronounced; profile-contour rises from thoracic junction at an angle of 30°, slopes forwards across three-fourths of caput; *clypeus* nearly equals diameter of a fore-central eye in depth.

Posterior row of *eyes* sensibly procurved, median pair separated by an interval which perceptibly exceeds their diameter; their space and a quarter from side-eyes; anterior row moderately recurved, centrals visibly smaller than posterior pair, have their lake-brown tinge and rings, interspace equal to about twice their diameter, rather less than that interval from hind-median eyes; about twice their space from side-eyes; laterals nearly equal hind-centrals in size, seated obliquely, visibly more than their radius from each other, on separate lake-brown tubercular eminences.

Legs moderately slender; reddish-chestnut colour; faint annuli; hairs light, sparse; spines slight, yellowish, moderately numerous; superior tarsal claws—1st pair, 10 teeth; inferior claw, 2 short close teeth.

Palpi and legs concolorous; slender, equal to cephalothorax in length; armature slight spines and hairs; palpal claw, curvature moderate, 8 teeth directed forwards.

Falces yellowish, apices and fangs dark; conical, vertical, project at base in front; length equal to breadth of anterior row of eyes.

Maxillæ strong, obtusely pointed, inclined towards *labium*: latter oval, about as broad as maxillæ, three-fourths their length; organs, base red-chestnut, apices yellowish.

Sternum colour of coxæ; shield-shape; clathrate.

Abdomen projects over base of cephalothorax; broadest between moderately pronounced tubercles, base obtusely pointed, tapers towards spinners; aplanate; hairs fine,

sparse; ground-colour creamy-brown; a moderately angular brown mark intersects anterior pair of impressed spots, which are in line with tubercles at its apex, which is directed forwards, is an oval yellowish spot, with orange-red margins; between central pair of impressed spots, which are also well defined, is a brown Y-shaped mark; few faint angular bars towards spinners. *Vulva* yellowish; convex, transversely rugulose; scapus large, somewhat conical, about as broad at base as long, lateral margins of basal half membranous, red-chestnut colour, prolonged margins curve inwards, forming somewhat triangular concavities beneath scapus vulvæ.

Single example, captured on summit of Te Aroha, *A. T. U.*

Epeira mulleola, sp. nov.

Male.—Ceph. th., long, 4·5; broad, 3·8. Abd., long, 4·5; broad, 3. Legs, 1, 2, 4, 3 = 15·5, 13·5, 12·4, 8·5 mm.

Cephalothorax, sides olive-brown, graduating to a reddish-brown on median line; moderately clothed with white hairs; sides well-rounded, laterally compressed forwards; pars cephalica somewhat depressed, shallow central indentation; lateral index slightly exceeds one-half facial index; ocular eminence prominent; pars thoracica moderately convex, indentation large, somewhat circular.

Posterior-central *eyes* separated from each other by a space equal to their diameter and a half; their breadth from fore-centrals; anterior median eyes perceptibly the largest, interval between them equals their diameter and a half; laterals seated on moderately strong, black, tubercular eminences, their radius apart; fore-pair visibly the largest.

Legs light-brown, tinted—especially 1–2—with light olive-green, fore-part of femora clouded with dark olive-brown; tibial, metatarsal, and tarsal joints annulated with olive-brown, less defined on tibiæ of 1–2; genual joints rather more than half length of tibial; latter articles equal metatarsal in length; tibia of a leg of 1st pair equal to cephalothorax in length; curved process on coxæ of 1; hairs yellowish, short, tolerably sparse; spines yellowish, base dark; several long spines on femora of 1–2; 3–4, superior and inferior row of about 4 or 5 spines, mostly exceeding former in length and strength; spines on genual joints; fairly numerous and strong on tibiæ, especially of 1–2; 10 to 15 spines on metatarsal joints; superior tarsal claws—1st pair, 11 open comb teeth; inferior claw sharply bent, 2 close teeth.

Palpi, hairs pale-yellow; humeral joint yellow-brown; short, fore-end somewhat dilated, furnished with a long, stout bristle; cubital joint yellowish; broad cordate, base constricted, more than half length of pars humeralis, projects at apex a long, strong, yellowish-brown bristle; radial joint

tinted with olive-brown; one-third length of former article, produced on outer side into a large, pale straw-coloured, oval process, directed outwards and slightly downwards; pars digitalis large, oval; laminæ bulbi yellowish, clouded with olive-brown; ovate, apices curved; directed towards each other; base prolonged on outer side into a reddish curved process, directed outwards; bulbus genitalis complex; crown light reddish-brown, clouded; somewhat oval, convex, horizontally rugose, on summit is a dark-reddish circular bead; bulb displays several curved, obtusely-pointed convolutions, yellowish-brown, blackish-red margins; most remarkable projections—view laterally, fore-lobe somewhat vertical in front, upper margin developed into a bright red-mahogany, semi-detached, broad, cylindrical, horizontal process, curving backwards, about its diameter below upper disc; projecting downwards from margin of disc is a large, bright mahogany-red, flattish, somewhat cordate lobe, apex curved forwards, in contact with apex of cylindrical process; between cordate lobe and a semi-pellucid black-marked membrane at articulation of bulb is a broad, blackish, longitudinally-wrinkled appendage, fore-end concave, hind limb claw-like, directed backwards; beneath cordate lobe is a large, brownish-lake, curved process, projecting outwards and somewhat forwards, nearly as broad as long, concave above, apex truncated, somewhat U-shaped.

Falces yellow-brown, basal two-thirds yellow, streaked with olive-green; vertical, moderately slender, outer contour concave, inner convex, fore-third directed outwards; fangs lake-colour.

Maxillæ, fore-end dilated, rather broader than lip, obtusely pointed, inclined towards each other. *Labium* rather broader than long, lateral margins abrupt, slope perceptibly outwards, obtusely pointed, everted; organs, base dark-brown, fore-end pale olive-brown.

Sternum blackish-brown; white hairs; ovate, transversely rugose.

Abdomen oviform, moderately prominent across greatest diameter; posterior end rounded, two well-developed tubercles, one above the other, lower perceptibly the largest; eight impressed spots; anterior pair of four central, well defined, placed at base of transverse ridge; ground-colour light slaty stone-colour; folium trilobate, margins black-brown, resembles females in form and marks; lateral margins tabby-grey; ventral surface brownish-yellow, shield blackish.

Female described in vol. xx. "Trans. N.Z. Inst."* This species is by no means rare, commences pairing in October: cocoon globose, composed of dark-green silk, of loose texture;

* "Trans. N.Z. Inst.," vol. xx., p. 118, and pl. xi., fig. 6.

comprised within are about 360 pinkish eggs, agglutinated together.

Tairoa, *T. Broun*; Te Karaka, *A. T. U.*

Fam. THLAOSOMIDÆ.

Genus **Thlaosoma**, Cambr.

Thlaosoma tuberosa, sp. nov.

Female.—Ceph. th., long, 2; broad, 2·7. Abd., long, 3·1; broad, 5. Legs, 1, 2, 4, 3 = 8·2, 8, 6, 5 mm.

Cephalothorax pale stone-colour, olive-tinge, base and lateral margins semi-pellucid, striæ defined by interrupted dark-brown streaks; pars cephalica brownish, light olive-brown oblique bars; median streak yellowish-brown, acute; eye-area reddish, cross yellow; hairs papillæform, white and reddish; pars thoracica somewhat reniform, raised into two abrupt ridges, terminating in prominent sub-conical points above thoracic junction; fore-part of pars cephalica somewhat conical, has the normal upturn; height of *clypeus* nearly equals depth of ocular area.

Four central *eyes* form a quadrilateral figure broader than long, of about equal size; laterals rather smaller than median eyes, their radius apart.

Legs brownish-yellow, broad, somewhat flecked, brown annuli on femora; two broad annulations on tibiæ; single one at fore-end of metatarsi; 1–2 and 3–4 of about equal strength, two fore-pairs stoutest; femoral joints armed beneath with double row of moderately short and strong tubercular spines, numerous smaller spines between rows; similar rows, composed of smaller spines, beneath tibiæ of 1–2; hairs sparse; outer superior tarsal claw—1st pair, much the longest and strongest, 4 close teeth; inner claw 5; inferior claw sharply bent, 2 short teeth.

Palpi and legs concolorous; palpal claw sharply curved, 3 teeth increasing in length and strength.

Falces clouded with blackish-olive, fangs red; long, somewhat linear, directed inwards.

Maxillæ rather longer than broad, roundly pointed, inclined over *labium*, which is large, broader than long, somewhat pointed; organs chocolate-brown, apices light.

Sternum olive-brown, clouded with dark-brown; cordate.

Abdomen, base and lateral margins have a pinkish tint; in centre of concave depression above thoracic junction is a linear-oval, red-brown mark; dorsal surface, except posterior third, which represents a creamy-white triangular area, is black-brown; tubercular eminences mostly yellowish-brown; hairs papillæform, numerous, reddish and white; the apices of the two lateral and leading protuberances are nipple-like;

these protuberances are shorter and more sharply constricted than in *T. olivacea*; on the darker portions are numerous fair-sized rounded humps; spinners stout, dark. *Corpus vulvæ* pale stone-colour, somewhat triangular, about twice as long as broad, centrally produced above the rima genitalis into a brownish lip, about as broad as long, concave above.

Te Karaka, *A. T. U.*

Fam. ATTIDÆ.

Genus **Plexippus**, C. Koch.

Plexippus herbigradus, sp. nov.

Male.—Ceph. th., long, 4; broad, 2·5. Abd., long, 4; broad, 2·1. Legs, 1, 4, 2, 3=8, 6·3, 5·6, 5·5 mm.

Cephalothorax, caput brownish, more or less suffused with bright orange-red, mottled with a creamy-brown penetrative tint; two dark spots in line with second row of eyes; thorax reddish-mahogany colour; few pale hairs, sparse yellowish fringe on frontal margin; broad oval, pars thoracica slightly exceeds pars cephalica in length, latter aplanate, limited by a somewhat diamond-shaped indentation; profile-contour rises at an angle of 45°, slopes perceptibly across caput; *clypeus* vertical, equal in height to radius of a fore-lateral eye.

Anterior row of *eyes* slightly recurved; laterals separated from central pair by nearly their diameter, latter pair rather less than that interval from each other; interspace between posterior eyes, which are visibly larger than anterior-laterals, perceptibly exceeds space dividing latter pair; eye-area about one-fourth broader than long; angles somewhat prominent, black-brown.

Legs brownish-yellow, genual and tibial joints of 1st pair reddish-mahogany, penultimate and terminal joints darkish-brown; 1st pair stoutest; genua and tibia together equal cephalothorax in length; tibial joint one-third longer than genual; metatarsal and tarsal joints thinner than tibial, one-fourth longer than that article; 2 slightly exceed 3–4 in strength, latter of about equal stoutness; hair light, sparse; about 5 spines on femora of 1–2; 6 or 7 on femora of 3–4; spine on inner side of genual joints of 1; tibiæ and metatarsi of 1–2,—3–3, 2–2; tibiæ of 3–4 have 4 spines; metatarsi 2, with rings of 5; outer claw, one strong tooth near bend of claw; inner, about 10 short close teeth; claws well curved, claw-tuft long.

Palpi, humeral and cubital joints resemble legs in colour; former article equals three terminal joints in length; pars cubitalis somewhat linear, rather stouter than humeral joint; pars radialis darker, slimmer, and about one-half length of

pars cubitalis, projects on outer side a stoutish process, apex fine, curved upwards; lamina bulbi mahogany-colour, moderately hairy; rather longer than two former articles together, apex obliquely truncated, slope directed outwards, somewhat depressed; bulbus genitalis chocolate-brown, nearly two-thirds length of lamina; viewed beneath, from inner side, somewhat triangular; projecting from apex are two moderately-long, fine, curved apophyses, inner black, outer pellucid; beneath lamina, on outer side, is a yellowish tumid bulb, whose free end extends backwards to radial joint.

Falces purple-chocolate; conical, vertical, transversely rugose; length equal to posterior breadth of ocular area.

Maxillæ red-mahogany colour; fore-end broad, rounded.

Labium linear-oval; colour of maxillæ.

Sternum reddish-brown; oval.

Abdomen linear-oviform; olive-tinted stone-colour, numerous light flecks on lateral margins and dorsal line; folium brownish, coarsely serrate, encloses a linear-oval, light olive-green mark, with few brown spots; series of three oblique brown streaks on lateral margins; ventral surface brownish; hairs sparse.

Female.—Ceph. th., long, 3; broad, 2. Abd., long, 4; broad, 2. Legs, 1st pair, 5mm.

Cephalothorax yellowish-mahogany, caput mottled with creamy-brown, fore-half clouded with a darkish-brown; few hairs on margin of eye-area; pars cephalica aplanate, sides moderately abrupt, limited by a somewhat diamond-shaped depression, scarcely equals length of pars thoracica; profile-line rises from thoracic junction at an angle of 45°, dips slightly forwards across caput; *clypeus* vertical, equals radius of a fore-lateral eye in depth; fringe of light hairs.

Angles of *eye-area* less prominent than males.

Legs brownish-yellow, anterior pair shade darker, especially four terminal joints; genual and tibial joints of 1 more than three-fourths length of cephalothorax; hairs sparse; few spines on femora; single spine on inner side of genua of 1; tibiæ of 1–2, as a rule, 3–4; metatarsi, 2–2; tibiæ of 3–4, about 4 or 5; metatarsi 2, rings of 5 spines.

Palpi and hind-legs concolorous; sparsely furnished with hairs; slender; length, 2·4mm.

Falces reddish-mahogany; broad conical, less pointed and shorter than males, vertical, transversely rugose.

Maxillæ brown; extremity broad, rounded. *Labium* brown; linear-oval, about half length of maxillæ.

Sternum oval; yellowish.

Abdomen linear-oviform; ground-colour deep stone-colour, numerous pale flecks; folium coarsely serrate, olive-brown, encloses a pale, mottled, lanceolate figure, with serrate mar-

gins, and about five dark spots; on lateral margins are a series of three oblique darkish streaks, converging towards spinners; ventral shield linear-ovate; normal dark hue. Abdomen sparsely clothed with hairs. *Vulva* red-mahogany; moderately prominent; displays above, two circular foveæ, divided by a longitudinal septum, whose breadth about equals their diameter; on the tumid margin, above the rima genitalis, are two bright reddish-mahogany circular convexities, connected by a broad ligament, whose breadth equals their diameter.

Examples of this species were captured on the summit of Te Aroha; were numerous—especially males—amongst the ferns up the Wairongomai Gorge. Individually they varied both in coloration and distinctness of pattern. *A. T. U.*

Art. XIII.—*On a new Species of* Gasteracantha, *from Norfolk Island.*

By A. T. Urquhart.

[*Read before the Auckland Institute, 22nd October, 1888.*]

Plate VII.

Fam. EPEIRIDÆ.

Genus **Gasteracantha**, Sund.

Gasteracantha ocillatum, sp. nov. Plate VII., figs. 1–3.

Female.—Ceph. th., long, 3·2; broad, 2. Abd., long, 6·5; broad, 16; to apex of posterior spines, 21·5. Legs, 4, 1–2, 3 = 10, 9, 7 mm.

Cephalothorax brown, clouded, more especially on caput and sides, with black; hairs sparse, short, yellowish; broad oval, slightly compressed forwards, pars cephalica squarely truncated, frontal contour between ocular eminence, which is low, and fore-lateral eyes perceptibly convex; caput limited by a rather deep transverse groove, which takes a procurved lunulate form on median line; base rises, somewhat abruptly, into two sub-conical prominences, divided by a longitudinal cleft nearly equal to base of prominences in width, connected with ocular eminence by two rather faint lateral striæ; pars thoracica somewhat depressed, radial striæ well defined; profile-contour of pars cephalica conical, slight slope across thorax; height of *clypeus* visibly exceeds diameter of an anterior central eye.

Four median *eyes* represent a trapezoid, whose anterior side is shortest; posterior pair sensibly the largest, more than twice their space from side-eyes of same row, separated from each other by rather more than twice their diameter,

scarcely that interval from anterior pair, which are visibly more than an eye's breadth and a half from one another; lateral eyes perceptibly smaller than centrals, seated obliquely, their radius apart, on a stout tubercular eminence.

Legs reddish-mahogany colour (brown-mahogany in second example); hairs black, few fine bristles; 1–2 of nearly equal length and strength; 4 exceeds 3 in length and somewhat in stoutness; superior tarsal claws—1st pair, moderately curved (apparently), 8 rather strong, open teeth; inferior claw long, bent, teeth (?); auxiliary claws.

Palpi tolerably slender, colour and armature of legs; palpal claw slightly curved, 7 open teeth, centrals longest.

Falces dull-black, lake tinge; stout, somewhat pyriform, directed moderately forwards, nearly equal in length radial and digital joints of palpus; double row of strong teeth, outer row 7.

Maxillæ stout, about as broad as long, somewhat semicircular, base constricted, slightly inclined towards *labium*, which is about as long as broad, somewhat conical, everted, rather more than one-half length of maxillæ; base of organs chocolate-brown, margins olive tinted yellow-brown.

Sternum elongate-cordate, well-defined eminences opposite coxæ, base tapers off to a tail-like point from posterior pair; brownish-black; large, circular, brownish-yellow spot between anterior pair of eminences.

Abdomen light-yellowish stone-colour, area enclosed by sigilla, from first pair slightly suffused with a dull olive-green (less defined in second example); fore and hind margins have a pale-olive hue, sparsely clouded with streaks of lake; lateral extremities, fore-spine, and base of hind-spine, black; fore-part of latter spine red-lake, apex dark; posterior spine-like tubercles lake-black; sigilla black, tinted more or less with brown-lake; centre and extremities of ventral surface greenish-black, intermediate longitudinal bands, which equal central in breadth, have a yellowish hue, suffused with lake; irregularly-shaped yellowish-coloured spots, base of two largest partially encircle spinners, tapering off round posterior margins of branchial opercula; few short black hairs on margins and posterior tubercles; horny; rather more than twice as broad as long, aplanate, lateral wing-like projections rise to an angle of 25°, terminate with stout spines directed outwards; anterior pair 1mm. in length, inclined slightly forwards; posterior pair, 4mm., curve moderately backwards; viewed from above, profile-contour of central third represents a visibly-depressed segment of a circle projecting over base of cephalothorax; extremities of line slope perceptibly backwards to anterior spines; from apex of posterior spines to base of tubercles profile-line forms a slight and even concavity; tuber-

cles, 2mm. long, directed backwards and visibly outwards; on dorsal margins are a series of sigilla, ten in each row (in one specimen eleven are represented in anterior row, the second outer sigillum on left side having a double form, probably abnormal); anterior row—central pair circular, smallest of series; outer sigillum large, ovate; between latter and inner sigillum are intermediate forms decreasing in size; in posterior row outer pairs of sigilla are smaller and of a linear-oval form; in centre of abdomen are four small linear-oval sigilla representing a trapezoid, whose posterior side is widest; from the tumid posterior margin abdomen dips abruptly, 4mm., to spinners; this area has, including the marginal, five well-developed transverse corrugations, first connects base of posterior lateral spines, second projects backwards, and bears the spine-like tubercles; three corrugations on ventral surface; in all grooves are small sigilla, ten in first row; at extremity of each wing-like projection is a large, blackish, ovate sigillum, equal to dorsal one in size. *Vulva* black; large, somewhat conical, apex rounded; viewed from posterior end displays a membranous ridge, terminating beyond base.

This species is closely allied to *Gasteracantha westringii*, from New Holland, described and figured by Koch in "Die Arachniden Australiens." Two examples were captured by Miss Lodge at Norfolk Island. I am indebted to Mr. T. F. Cheeseman, F.L.S., for the specimens which he handed over to me for determination.

DESCRIPTION OF PLATE VII.

Gasteracantha ocillatum.

Fig. 1. Female.
Fig. 2. Maxillæ, lip, and sternum.
Fig. 3. Posterior view.

Art. XIV.—*Descriptions of New Zealand* Micro-Lepidoptera.

By E. Meyrick, B.A., F.E.S.

[*Read before the Philosophical Institute of Canterbury, 1st Nov., 1888.*]

The following descriptions include all the material remaining undescribed in my hands of these groups. It is for resident collectors to obtain fresh material and information on the habits of described species, and I shall at all times welcome any communication from those who have the opportunity of doing so, and will gladly determine any species sent to me.

BOTYDIDÆ.

MNESICTENA, Meyr.

1. *Mnes. daiclealis*, Walk.

(*Scopula daiclesalis* (rect. *daiclealis*), Walk., 1017.)

♂. 22mm. Head and thorax deep ferruginous. Palpi 4, deep ferruginous, sprinkled with dark grey; base white beneath. Antennæ pale ochreous. Abdomen light ochreous-yellowish. Legs pale ochreous, anterior tarsi and middle tibiæ white. Forewings triangular, costa slightly sinuate in middle, strongly arched on posterior half, apex tolerably rectangular, hindmargin rather bowed, oblique; ferruginous-brown, irrorated with dark grey; inner margin rather broadly suffused with ochreous-orange from base to $\frac{3}{4}$; a narrow ochreous-orange streak along costa from base to $\frac{3}{4}$, enclosing a very slender snow-white costal streak from $\frac{1}{4}$ to $\frac{2}{3}$; lines thick, cloudy, dark grey, very indistinctly defined; first about $\frac{1}{4}$, oblique, not reaching either margin; second from $\frac{3}{4}$ of costa to $\frac{2}{3}$ of inner margin, upper $\frac{2}{3}$ moderately curved outwards; reniform obscurely outlined with dark grey, very indistinct: cilia ferruginous-brown suffused with grey. Hindwings light ochreous-yellowish; a dark-grey dot in centre of disc; partial indications of a slender greyish line at $\frac{2}{3}$; cilia pale whitish-yellowish, reddish-tinged.

Wellington and Dunedin. I am indebted, for the opportunity of describing this species to the liberality of Mr. G. V. Hudson, who states that it is attracted by light, and is scarce.

SCOPARIADÆ.

SCOPARIA, Hw.

2. *Scop. hemiplaca*, n. sp.

♂. 18mm. Head, palpi, antennæ, and thorax dark fuscous; palpi $2\frac{1}{4}$, base white beneath; antennal ciliations $\frac{1}{3}$. Abdomen light grey, and tuft whitish-ochreous. Legs dark fuscous, apex of joints and posterior tibiæ whitish. Forewings elongate, moderately dilated posteriorly, costa slightly arched, apex obtuse, hindmargin almost straight, rather oblique, rounded beneath; dark fuscous, with purplish reflections; first line obscurely indicated on lower half only, slightly paler than ground-colour; a suboblong white blotch, sprinkled with fuscous, extending along inner margin from middle to hindmargin, reaching half across wing, its upper anterior angle rounded off, upper side shortly indented in middle; this blotch is sharply defined, and margined in front and above by a thick black suffusion, in which the lower half of reniform is indicated by an obscure spot of ground-colour;

second line slightly paler than ground-colour, darker-margined, forming a whitish dot on costa, becoming obsolete on the white blotch, but its margins partially indicated by fuscous scales; an erect wedge-shaped white subapical spot; a white entire hindmarginal line: cilia ochreous-whitish, with an interrupted dark-grey line, and on upper half of hindmargin with obscure light-grey bars. Hindwings 1¼; pale grey; indications of a faint paler postmedian line; cilia ochreous-whitish, with an interrupted grey line.

Wellington; one specimen received from Mr. G. V. Hudson, who bred it from a larva feeding on moss. It is a conspicuously-distinct species, at once recognised by the peculiar white blotch; its nearest known ally is *S. minusculalis*.

TORTRICIDÆ.

Cacœcia, Hb.

3. *Cac. astrologana*, n. sp.

♂. 16–22mm. Head, palpi, antennæ, thorax, abdomen, and legs pale whitish-ochreous; palpi long; anterior legs infuscated. Forewings elongate-triangular; costa strongly arched, apex obtuse, hindmargin slightly sinuate, somewhat oblique, costal fold short; whitish-ochreous, with a few fine scattered black scales; a small black dot in disc before middle, a second in disc at ⅔ (in Tasmanian specimen absent), a third beneath costa at ⅘, a fourth in disc at ⅘, and a fifth towards inner margin at ⅔: cilia pale whitish-ochreous. Hindwings whitish, with a few scattered light-grey speckles; cilia whitish.

Wellington; one specimen received from Mr. G. V. Hudson. I took a specimen also at Deloraine, Tasmania, in November; the species is very distinct, and I have no doubt of their identity.

Proselena, Meyr.

4. *Pros. eribola*, n. sp.

♂. 14–15mm. Head, palpi, and thorax dark reddish-ochreous-brown. Antennæ brownish-ochreous, ringed with dark fuscous. Abdomen dark fuscous. Legs dark fuscous, apex of joints pale yellowish, posterior tibiæ pale greyish-ochreous. Forewings oblong, posteriorly scarcely dilated, costa on basal half rather strongly arched, then straight, apex obtuse, hindmargin slightly sinuate, somewhat oblique; dark reddish-ochreous-brown; a somewhat darker but very ill-defined central fascia from before middle of costa to inner margin before anal angle, narrow on costa, suddenly dilated above middle, thence to inner margin rather broad: cilia dark reddish-ochreous-brown, terminal half pale reddish-ochreous, on costa barred with dark brown. Hindwings and cilia dark

fuscous; tips of cilia shortly below apex sometimes pale reddish-ochreous.

Otira River (3,000ft.), amongst forest, in January; four specimens. A distinct species, perhaps nearest *P. zatrophana*.

GLYPHIPTERYGIDÆ.

HELIOSTIBES, Z.

5. *Hel. electrica*, n. sp.

♀. 16–17mm. Head, palpi, thorax, and abdomen dark fuscous, slightly sprinkled with yellowish. Antennæ and legs dark fuscous, posterior tibiæ yellow-whitish. Forewings elongate, moderate, costa gently arched, apex rounded, hindmargin obliquely rounded; dark fuscous, strewn with ochreous-yellow hair-scales in irregular patches; a leaden-metallic line from $\frac{1}{3}$ of costa to $\frac{2}{3}$ of inner margin, angulated outwards in middle; a sinuate leaden-metallic line from above middle of disc to anal angle; a leaden-metallic line from middle of costa obliquely outwards more than half across wing, thence curved round to touch a whitish dot on costa at $\frac{3}{4}$, and continued in a strong curve near and parallel to costa and hindmargins to anal angle; space between first and second lines, and within first curve of third line, less strewn with yellow scales and therefore darker than rest of wing: cilia light grey, rather shining. Hindwings rather dark fuscous, somewhat bronzy; cilia light shining grey.

Mount Arthur (4,700ft.), in January; two specimens. Very distinct.

PLUTELLIDÆ.

EUTORNA, n. g.

Head smooth, sidetufts projecting over forehead; ocelli absent; tongue well-developed. Antennæ $\frac{4}{5}$, in male serrate, shortly ciliated ($\frac{1}{2}$–$\frac{1}{3}$), basal joint moderately long, without pecten. Labial palpi long, curved, ascending, second joint thickened with dense appressed scales, terminal joint shorter than second, slender, acute. Maxillary palpi very short, drooping. Posterior tibiæ clothed with hairs above. Forewings with vein 1 furcate, 2 from very near angle, 6 to apex, 7 and 8 stalked, 11 from before middle. Hindwings almost or quite as broad as forewings, elongate-ovate or broadly lanceolate, cilia $1\frac{1}{3}$; all veins separate, 5 bent.

Approaches most nearly to *Compsistis*, from which it differs mainly in the antennæ not being as long as forewings, and in veins 3 and 4 of the hindwings being separate. Besides the two following species I have several Australian, which are closely allied to them:—

Ground-colour of forewings ferruginous-brown	..	*caryochroa.*
" " " ochreous ..	..	*symmorpha.*

6. *Eut. caryochroa*, n. sp.

♂ ♀. 11–12mm. Head ferruginous-brown, face whitish-ochreous. Palpi ochreous-white, apex of second joint ochreous, terminal joint almost as long as second, dark fuscous. Antennæ fuscous, ringed with black. Thorax ferruginous-brown, shoulders pale ochreous. Abdomen fuscous. Legs dark fuscous, ringed with ochreous-whitish. Forewings elongate, narrow, costa moderately arched, more strongly towards base, apex round-pointed, hindmargin extremely obliquely rounded; rather dark ferruginous-brown; an upwards-curved yellowish-white streak from middle of base to $\frac{3}{5}$ of disc, margined beneath with blackish, above with bright yellow-ochreous, which extends to costa towards base; a slender white oblique streak from $\frac{1}{3}$ of costa to middle of disc, margining a triangular costal suffused patch of purplish-grey and whitish scales, beneath which is sometimes a longitudinal blackish suffusion; a black dot in disc at $\frac{2}{3}$, surrounded by a yellowish-white ring; some purplish-grey scales towards posterior half of inner margin; a small white spot on costa at $\frac{4}{5}$, beyond which is a blackish suffusion; an obscure irregular whitish streak along hindmargin, followed by some black scales: cilia ochreous, towards anal angle greyish-tinged, round apex with a white median line preceded and followed by fuscous shades. Hindwings rather dark bronzy-fuscous; cilia fuscous-grey.

Castle Hill (2,500ft.), Dunedin, Lake Wakatipu, and Invercargill; in December and January, rather common.

7. *Eut. symmorpha*, n. sp.

♂ ♀. 12–14mm. Head and thorax yellow-ochreous, face whitish-ochreous. Palpi yellow-ochreous, terminal joint much shorter than second, whitish. Antennæ ochreous-whitish, ringed with pale fuscous, towards base ochreous. Abdomen whitish-ochreous. Legs whitish-ochreous, tarsi and anterior tibiæ more or less infuscated. Forewings elongate, narrow, costa moderately arched, more strongly near base, apex round-pointed, hindmargin extremely obliquely rounded; yellow-ochreous, sometimes obscurely streaked with whitish-ochreous between veins, veins more reddish-ochreous or brownish-ochreous; a straight, slender, reddish-brown streak from middle of base to disc at $\frac{1}{3}$, terminating in a small blackish spot, cloudy beneath, above sharply-defined and sometimes margined with an ochreous-whitish streak; a more or less distinct reddish-brown streak from disc before middle to costa before apex, terminating in some black scales; two black dots transversely placed in disc at $\frac{2}{3}$; some black scales on hindmargin: cilia pale ochreous, round apex with an ochreous-brown line. Hindwings and cilia light grey.

Whangarei, Hamilton, Palmerston, Napier, Christchurch, Dunedin, and Invercargill; from December to March, common.

HYPONOMEUTIDÆ.

ARCHYALA, n. g.

Head with loosely-appressed hairs; ocelli present; tongue developed. Antennæ ⅘, in male serrate, pubescent, basal joint moderate, without pecten. Labial palpi moderately long, curved, ascending, second joint with rough projecting scales towards apex beneath and two or three apical bristles above, terminal joint shorter than second, somewhat loosely scaled, laterally compressed, obtuse. Maxillary palpi rather short, appressed to face. Posterior tibiæ clothed with long hairs above and beneath. Forewings with vein 1 furcate, 2 from angle of cell, 7 and 8 stalked, 7 to costa, 11 from middle. Hindwings 1, elongate-oblong, apex round-pointed, hindmargin very oblique, cilia 1; with an ill-defined hyaline patch towards base; veins 2, 3, 4 remote and parallel, 5 and 6 stalked, 6 to close below apex, 7 approximated to 6 at base.

Nearly allied to *Lysiphragma*, but separable by the stalking of veins 7 and 8 of forewings, absence of scaletufts on surface, and hyaline patch of hindwings.

8. *Arch. paraglypta*, n. sp.

♂. 16mm. Head fuscous-whitish, more fuscous between antennæ. Palpi dark fuscous, terminal joint whitish. Antennæ fuscous. Thorax fuscous, posteriorly mixed with whitish. Abdomen fuscous. Anterior legs dark fuscous ringed with whitish, middle legs ochreous-white banded with black, posterior legs ochreous-whitish banded with fuscous. Forewings very elongate, narrow, costa moderately arched, apex round-pointed, hindmargin extremely obliquely rounded; white, irregularly transversely strigulated with grey, and more or less suffused with pale brownish-ochreous except towards inner margin and base, and on costal edge; numerous irregular incomplete transverse dark fuscous strigulæ, tending to partially coalesce in pairs: cilia grey-whitish, base white, round apex with a black median line and barred with fuscous. Hindwings bronzy-fuscous; cilia whitish-grey.

Christchurch; one specimen amongst bush, in January.

ENDROSIS, Hb.

Head smooth; ocelli present; tongue developed. Antennæ ⅘, in male strongly ciliated (2½), basal joint moderate, with pecten. Labial palpi long, curved, ascending, with appressed scales, terminal joint somewhat shorter than second, acute. Maxillary palpi very short, appressed to tongue.

Posterior tibiæ clothed with long hairs above. Forewings with vein 1 furcate, 2 from $\frac{3}{4}$ of cell, 4 and 5 approximated at base, 7 and 8 stalked, 7 to costa, 11 from before middle. Hindwings somewhat narrower than forewings, elongate, long-pointed, tolerably acute, cilia 2; with an ill-defined hyaline patch towards base; veins 3 and 4 stalked, 5 absent, 6 and 7 parallel.

Only the one species is known. Stainton and Wocke both state the ocelli to be absent; they are, however, distinct, but placed close beneath the root of the antennæ, and therefore easy to be overlooked. A more singular and unaccountable error is that both these writers describe the antennæ as not ciliated, whereas the ciliations are unusually long for this group.

9. *Endr. lacteella*, Schiff.

(*Gelechia subditella*, Walk., 657; (?) *G. adapertella*, ib., 658.)

♂ ♀. 13–18mm. Head and thorax white. Palpi white, terminal joint with base and a subapical band black. Forewings elongate, narrow, pointed; pale greyish-ochreous, sprinkled with dark fuscous and a few white scales; a white basal dot; a basal patch enclosing this, a patch along costa towards middle, a small cloud on middle of inner margin, one at anal angle, and another at apex fuscous; a black dot beneath costa at $\frac{1}{4}$, a second, longitudinally elongate, rather obliquely beyond it on fold, a third beneath middle of costa, and a fourth in disc at $\frac{3}{5}$: cilia pale whitish-ochreous, basal half sprinkled with dark fuscous. Hindwings whitish-grey; cilia pale whitish-ochreous.

Whangarei, Napier, Taranaki, Palmerston, Wellington, Christchurch, Bealey River, and Invercargill, probably therefore universally distributed; in houses, from October to March. Accidentally introduced from Europe, and common in Australia also; the larva feeds on seeds, dried foods, &c. Walker's type of *Gelechia adapertella* is much damaged, and its identification not quite certain.

BUTALIS, Tr.

Head smooth; ocelli present; tongue well-developed. Antennæ $\frac{4}{5}$, in male filiform, shortly ciliated ($\frac{1}{2}$–1), basal joint moderate, without pecten. Labial palpi moderately long, curved, ascending, with appressed scales, terminal joint shorter than second, pointed. Maxillary palpi very short, slender, drooping. Posterior tibiæ clothed with long hairs above. Forewings with vein 1 simple or rarely shortly furcate, 2 from angle of cell, 3 absent, 7 and 8 stalked, 7 to hindmargin, 11 from about middle. Hindwings $\frac{1}{2}$ to almost 1, lanceolate, cilia 1–4; veins all separate, and tolerably parallel.

A genus of considerable extent; it is cosmopolitan, but

apparently most developed in Europe. The single New Zealand species approaches most to some of the Australian.

10. *But. epistrota*, n. sp.

♂ ♀. 10–11mm. Head, palpi, antennæ, thorax, abdomen, and legs rather dark grey, slightly bronzy-tinged, generally somewhat sprinkled with whitish; antennal ciliations $\frac{1}{2}$; abdomen in female whitish beneath. Forewings lanceolate; rather dark bronzy-grey, more or less densely strewn with whitish scales; in paler specimens there are indications of two very ill-defined inwardly oblique darker streaks on anterior half, more distinctly spotted with darker on fold, and two less perceptible outwardly oblique streaks on posterior half; an obscure round dark fuscous dot in disc at $\frac{3}{4}$: cilia pale bronzy-grey. Hindwings $\frac{2}{3}$, grey; cilia 2, pale bronzy-grey.

Christchurch (on the Lyttelton volcanic hills) and Mount Arthur (4,500ft.), in January; locally common.

TINEIDÆ.

HABROPHILA, n. g.

Head shortly rough-haired; ocelli present; tongue short. Antennæ in male—(?), filiform, basal joint moderately long, with strong pecten. Labial palpi long, slightly curved, somewhat ascending, second joint beneath with short, dense, rough, projecting tuft of scales towards apex; terminal joint much shorter than second, somewhat loosely scaled, tolerably obtuse. Maxillary palpi moderate, loosely scaled, folded. Posterior tibiæ with a few hairs beneath. Forewings with vein 1 simple, 2 from $\frac{3}{4}$ of cell, 5 and 6 approximated at base, 7 and 8 approximated at base, 7 to costa, 11 from before middle. Hindwings $\frac{2}{3}$, lanceolate, cilia $2\frac{1}{2}$; veins 2, 3, 4, remote and parallel, 5 and 6 stalked, 6 to hindmargin, 7 remote.

Allied to *Endophthora*. The single specimen has the apex of both antennæ broken, and their length is uncertain.

11. *Habr. compseuta*, n. sp.

♀. 11mm. Head, palpi, antennæ, and thorax whitish-ochreous, with a few dark fuscous scales. Abdomen ochreous-whitish. Legs pale whitish-ochreous, anterior pair infuscated. Forewings very elongate, narrow, parallel-sided, short-pointed; whitish-ochreous, suffusedly irrorated with dark fuscous, less towards base; costa marked with blackish-fuscous; a blackish dot on inner margin almost at base; an irregular series of blackish scales along fold; a small whitish spot on costa at $\frac{1}{3}$; a large oblique subquadrate white spot on costa slightly before middle, reaching nearly half across wing; a small round black spot in disc before $\frac{2}{3}$, preceded by some blue-metallic scales;

posterior half of wing suffused with golden-fuscous, crossed posteriorly by two slender angulated leaden-blue-metallic fasciæ, margined by series of white dots; hindmargin dotted with blackish and white: cilia ochreous-grey-whitish. Hindwings whitish-grey; cilia grey-whitish.

Mount Arthur (4,000ft.), in January; one specimen.

ARGYRESTHIADÆ.

Head more or less rough on crown, face smooth. Antennæ in male simple. Maxillary palpi obsolete. Forewings usually with a rough space on costa between veins 11 and 12.

The family is fairly well represented in Australia. I have only five New Zealand species, of which perhaps three are scarcely indigenous, but of Australian or exotic origin.

1.	Forewings with vein 5 absent	3.
	" " present	2.
2.	Forewings with veins 7 and 8 stalked	*Circostola.*
	" " separate	*Hofmannia.*
3.	Forewings with vein 10 absent	*Cateristis.*
	" " present	*Bedellia.*

HOFMANNIA, Wk.

Head rough on crown, face smooth; ocelli present; tongue developed. Antennæ $\frac{3}{4}$, in male simple, subserrate, basal joint moderate, with pecten. Labial palpi moderately long, slightly curved, drooping, filiform, somewhat loosely scaled beneath, terminal joint shorter than second, sometimes more loosely scaled, tolerably pointed. Maxillary palpi obsolete. Posterior tibiæ smooth-scaled. Forewings with vein 1 furcate, 2 from near angle of cell, 7 to hindmargin, 9 and 10 sometimes from a point, 11 from about middle. Hindwings 1, lanceolate, cilia 2; vein 4 absent, 5 and 6 rather approximated, 6 to hindmargin.

A small genus, occurring in Europe and Australia.

12. *Hofm. sphenota*, n. sp.

♂. 13mm. Head and antennæ light ochreous-grey. Palpi grey. Thorax light ochreous. Abdomen whitish-ochreous. Legs fuscous, posterior pair ochreous-whitish. Forewings very elongate, very narrow, parallel-sided, long-pointed, acute; pale ochreous, thinly and irregularly sprinkled with dark fuscous and whitish; basal half of costa dotted with black; a moderately-broad ill-defined cloudy-white streak along inner margin from base to anal angle, pointed at extremities, interrupted at $\frac{2}{3}$ by a small spot of ground-colour; a cloudy inwardly-oblique dark fuscous mark at $\frac{1}{3}$ from near costa to near inner margin: cilia ochreous-grey-whitish, round apex ochreous, with base white, a grey line, and three cloudy dark grey bars. Hindwings pale whitish-grey; cilia ochreous-grey-whitish.

Christchurch; one specimen amongst bush, in August. This species closely approaches an Australian form, and, my material being scanty, I am not sure that they are not to be regarded as local races only; however, at present I am disposed to consider them as distinct.

CIRCOSTOLA, n. g.

Head loosely scaled, rather rough behind, face smooth; ocelli present; tongue developed. Antennæ $\frac{4}{5}$, in male simple, filiform, basal joint moderate, with pecten of two or three fugitive scales. Labial palpi moderately long, curved, somewhat ascending, second joint with loose rough scales beneath towards apex, terminal joint somewhat shorter than second, loosely rough-scaled anteriorly, pointed. Maxillary palpi obsolete. Posterior tibiæ smooth-scaled. Forewings with vein 1 simple, 2 from $\frac{4}{5}$ of cell, 7 and 8 stalked, 7 to hindmargin, 11 from $\frac{1}{3}$. Hindwings 1, lanceolate, hindmargin sinuate beneath apex, cilia $1\frac{2}{3}$; vein 4 absent, 5 and 6 rather approximated, 6 to hindmargin.

Intermediate in some respects between *Zelleria* and *Argyresthia*. The head is less rough than in any other genus of the family. Only the one species is known to me.

13. *Circ. copidota*, n. sp.

♂ ♀. 15–16mm. Head white, face ochreous-tinged. Palpi reddish-fuscous, terminal joint suffused with whitish. Antennæ ochreous-whitish, ringed with dark fuscous. Thorax white, shoulders ochreous-tinged. Abdomen ochreous-whitish. Legs whitish, anterior and middle pair irrorated and suffusedly tinged with dark fuscous. Forewings very elongate, narrow, costa strongly arched, apex very acute, produced, hindmargin obsolete; pale brownish-ochreous, with a few dark fuscous and whitish scales; a broad whitish streak along inner margin from base to middle, posteriorly attenuated to a point, and sometimes suffused, margined above by an irregular slender streak of black scales from base not reaching its apex; from extremity of this a slender irregular darker ochreous-brown suffused streak to apex of wing, marked with indications of blackish dots at $\frac{2}{3}$ and apex: cilia pale whitish-ochreous, nearly white on costa at $\frac{3}{4}$, above apex brownish-ochreous, with a suffused blackish apical bar. Hindwings and cilia ochreous-grey-whitish.

Nelson, Wellington, Otira River (1,500ft.), and Lake Wakatipu (1,200ft.), in December and January; rather common amongst forest.

CATERISTIS, n. g.

Head rough on crown, face smooth; ocelli present; tongue developed. Antennæ $\frac{4}{5}$, in male simple, serrate, basal joint

moderately elongate, with large, dense, strong pecten. Labial palpi very short, filiform, drooping. Maxillary palpi obsolete. Posterior tibiæ densely clothed with very long hairs above and beneath. Forewings with vein 1 simple, 2, 3, and 4 almost from a point, 5 and 6 absent, cell open between 4 and 7, 7 and 8 stalked, 7 to hindmargin, 10 absent, 11 from middle. Hindwings ⅗, lanceolate, cilia 3; veins 3, 4, 5 absent, cell open between 2 and 6, 6 and 7 stalked, 6 to hindmargin.

The natural group to which this and the following genus belong I formerly regarded as a distinct family (*Bedelliadæ*), separable from the *Argyresthiadæ* proper by the hairy posterior tibiæ and degraded neuration of hindwings; but from a study of more extensive material I think it better to unite them. The structure of the head is characteristic and identical, and the change of neuration is gradual.

14. *Cat. eustyla*, n. sp.

♂. 10–11mm. Head and thorax white, face grey. Palpi dark fuscous. Antennæ whitish-grey. Abdomen grey. Legs dark grey, tarsi ringed with white, middle and posterior tibiæ grey-whitish. Forewings lanceolate; snow-white; costa slenderly dark fuscous from about ¼ to ¾: cilia light grey, towards base whiter, round apex wholly white or ochreous-white, with a grey dot. Hindwings and cilia light grey.

Christchurch; one specimen amongst bush, in December. Also from Tasmania; the specimens from these two localities are absolutely similar.

Bedellia, Stt.

Head densely rough-haired above, face smooth; ocelli present; tongue short. Antennæ 1, in male filiform, simple, basal joint rather stout, with large dense pecten. Labial palpi short, porrected, slender, pointed. Maxillary palpi obsolete. Posterior tibiæ clothed with hairs above. Forewings with vein 1 simple, 2 from angle of cell, 3 from point with 2 or absent, 4 and 5 absent, 6 out of 8 or absent, 7 out of 8, running to hindmargin, 9 from point with 8, 11 from middle of cell. Hindwings ½, linear-lanceolate, cilia 6; no cell, veins 2, 3, 4 on a common stalk, 4 to apex, 5, 6, 7 absent.

15. *Bed. somnulentella*, Z.

♂ ♀. 8–9mm. Head whitish-ochreous, somewhat mixed with fuscous. Thorax whitish ochreous, in front fuscous. Forewings lanceolate; vein 3 absent, 6 out of 8; pale greyish-ochreous, suffusedly irrorated with fuscous except on a streak along inner margin: cilia light ochreous-grey, on costa ochreous-whitish. Hindwings grey; cilia light ochreous-grey.

Larva mining blotches in leaves of *Convolvulus* and *Ipomœa;* pupa naked, suspended.

Dunedin; bred freely from the larva by Mr. A. Purdie. Occurs usually from September to November. Probably an introduced species, found in Europe, North America, and throughout Australia.

16. *Bed. psamminella*, n. sp.

♂ ♀. 9–10mm. Head light ochreous, crown mixed with dark fuscous. Palpi fuscous. Antennæ fuscous-whitish. Thorax and abdomen pale ochreous. Legs whitish-ochreous, anterior and middle pair infuscated. Forewings lanceolate; vein 3 present, 6 absent; pale brownish-ochreous, with a few minute black irrorations towards costa posteriorly; a small black dot on inner margin at ⅓ of wing: cilia pale brownish-ochreous. Hindwings light grey; cilia pale ochreous-grey.

Taranaki, Christchurch, and Dunedin, in September, and from December to February; common.

ELACHISTIDÆ.

Head smooth. Labial palpi curved, ascending, pointed. Maxillary palpi rudimentary. Hindwings lanceolate or linear.

In this family, as in the preceding, there is a strong tendency to degradation in the neuration. Where this exists, the neuration must not in all instances be considered of equal importance; in some cases the disappearance of one or two veins must be regarded as insufficient to warrant generic separation, where no variations appear in the other structure. The New Zealand indigenous species seem to be entirely of an Australian or South Pacific character.

1. Basal joint of antennæ dilated into a large eye-cap	2.
Basal joint of antennæ not dilated	3.
2. Antennæ in ♂ with very long ciliations ..	*Vanicela.*
" " naked	*Calicotis.*
3. Antennæ in ♂ with very long ciliations ..	*Stathmopoda.*
" " shortly ciliated or naked ..	4.
4. Terminal joint of palpi longer than second ..	5.
" " " not longer than second ..	6.
5. Antennæ in ♂ ciliated	*Limnœcia.*
" " not ciliated	*Proteroœcema.*
6. Forewings with all veins present	7.
" " one or more veins absent ..	8.
7. Forewings with veins 7 and 8 stalked	*Syntomactis.*
" " " " separate ..	*Thylacosceles.*
8. Forewings with vein 11 absent	*Zapyrastra.*
" " " present, from middle of cell	9.
9. Terminal joint of palpi somewhat roughened anteriorly	*Batrachedra.*
Terminal joint of palpi smooth, slender ..	*Elachista.*

Vanicela, Walk.

Head smooth; ocelli present; tongue developed. Antennæ almost 1, in male serrate, with very long fine ciliations (4), basal joint very broadly dilated and excavated beneath to form a large eyecap, with small pecten. Labial palpi long, curved, ascending, second joint smooth-scaled, terminal joint somewhat roughened above, as long as second, acute. Maxillary palpi very short, drooping. Anterior tibiæ and tarsi rather dilated with scales; posterior tibiæ and basal joint of tarsi clothed with stiff rough spines above, inner middle-spur spinose above on basal half, two basal joints of tarsi with short apical spines. Forewings with vein 1 furcate, 2 from ⅔ of cell, 7 to costa, 7 and 8 approximated at base, 11 from ⅔ of cell. Hindwings ½, linear, cilia 6; veins 2, 3, 4 parallel, 5, 6, 7 approximated at base.

A curious genus, allied to *Stathmopoda*, but very distinct. In repose the dilated anterior legs are extended in front; the posterior legs are not erected, but appear to be usually appressed to the abdomen, without touching the surface on which the insect rests. Only the two species are known to me.

17. *Van. disjunctella*, Walk.

(*Vanicela disjunctella*, Walk., 1,089.)

♂ ♀. 13–15mm. Head, palpi, antennæ, and abdomen white. Thorax white, posterior half dark bronzy-fuscous. Legs white, base of tarsal joints spotted with dark fuscous. Forewings linear, long-pointed; shining white, slightly yellowish-tinged; a dark bronzy-fuscous streak occupying dorsal half of wing, its upper margin notched at ¼, with a short oblique indentation in middle, opposite which is a white dot on inner margin, and with a short projection at ¾; beyond ¾ are one or two very fine dark fuscous longitudinal lines; apex irrorated or spotted with dark fuscous: cilia grey, with a black apical hook. Hindwings and cilia grey.

Whangarei, Auckland, Taranaki, Palmerston, Nelson, Masterton, and Wellington; apparently, therefore, universal throughout the North Island, but not yet met with in the South: common from December to March, amongst forest. The following undoubtedly distinct Australian species is so extremely similar that I describe it here for purposes of comparison.

18. *Van. xenadelpha*, n. sp.

♂ ♀. 12–15mm. Head, palpi, antennæ, and abdomen white. Thorax white, posterior half dark bronzy-fuscous. Legs white, base of tarsal joints obliquely streaked with dark fuscous. Forewings linear, long-pointed; shining white, faintly yellowish-tinged; a dark bronzy-fuscous streak occupy-

ing dorsal half of wing, its upper margin not notched, cut in middle by a slender inwards-angulated white line reaching inner margin, and with a very minute projection at $\frac{3}{4}$; a white dot on inner margin at $\frac{1}{4}$; a fine black longitudinal line in disc towards apex: cilia grey, with a black apical hook. Hindwings and cilia grey.

Sydney, New South Wales; only on the fence of the Botanical Gardens, where it is common from September to December. Readily distinguished from the preceding by the white dot on inner margin of forewings at $\frac{1}{4}$, the absence of the notch on dorsal streak, the junction of the central indentation and dot into an angulated line, and the minuteness of the projection at $\frac{3}{4}$; these differences are entirely constant.

STATHMOPODA, Stt.

Head smooth; ocelli present; tongue developed. Antennæ $\frac{3}{4}$, in male with very long fine ciliations (4–5), basal joint elongate, without pecten. Labial palpi very long, recurved, slender, smooth-scaled, terminal joint as long as second, acute. Maxillary palpi very short, drooping. Posterior tibiæ clothed with rough hairs above, posterior tarsi with projecting bristles at apex of two basal joints. Forewings with vein 1 furcate, 2 from near angle of cell, 2 and 3 sometimes partially obsolete, 7 and 8 stalked, 7 to costa, 11 from beyond $\frac{3}{4}$. Hindwings $\frac{1}{3}$, linear-lanceolate, cilia 6; veins 2, 3, 4, 5 tolerably parallel, cell open between 5 and 6, 6 and 7 from a point.

This genus (of which the neuration is incorrectly given both by Stainton and Wocke) is represented in Europe by only one species (for the so-called *Stathmopoda guerinii* is generically quite distinct); but from Australia and New Zealand I have over thirty species, though the genus does not seem to have been identified elsewhere. It forms the type of a group, generally recognisable by the recurved palpi being directed sideways instead of forwards, the apical bristles of the tarsal joints, and the exceptional posture of the hindlegs in repose. In *Stathmopoda* the hindlegs are erected more or less perpendicularly over the back, the tarsi usually bent more sideways; but in some Australian species the insect does not always assume this posture, and sometimes does it with one leg only. Probably this attitude may be designed to deceive enemies by its unnatural appearance; it does not seem to imitate anything in particular. The occasional obsolescence of veins 2 and 3 of the forewings is an interesting phenomenon; from the examination of a good many denuded specimens I find no stress is to be laid on it; the obsolescence begins at the base of the veins, and appears in various degrees, sometimes only the extreme tips of the veins remaining. The genus differs from all others of the family, except *Vanicela*, by the very long

antennal ciliations of the male. I may add that the European and North American genus *Schreckensteinia*, Hb. (*Chrysocorys*, Curt.), belongs to this group.

1. Forewings without markings	*holochra.*
" with markings	2.
2. Forewings deep ochreous-yellow	*phlegyra.*
" whitish-ochreous or whitish	3.
3. Forewings with a dark fuscous V-shaped anterior mark	*campylocha.*
" without a dark fuscous V-shaped anterior mark	4.
4. Posterior tibiæ with conspicuous black apical ring of scales	*epichlora.*
" " without conspicuous black apical ring of scales	*skelloni.*

19. *Stath. holochra*, n. sp.

♀. 14mm. Head, palpi, antennæ, and abdomen pale whitish-ochreous. Thorax whitish-ochreous, slightly reddish-tinged. Legs pale whitish-ochreous. Forewings elongate, very narrow, broadest near base, long-pointed; pale reddish-ochreous, unicolorous: cilia pale whitish-ochreous-grey. Hindwings pale whitish-grey, posteriorly ochreous-tinged; cilia pale whitish-ochreous-grey.

Wellington; one specimen in December.

20. *Stath. phlegyra*, n. sp.

♂♀. 12–16mm. Head, palpi, and antennæ whitish-ochreous. Thorax ochreous-yellowish, shoulders and a central spot sometimes greyish-tinged. Abdomen pale whitish-ochreous, greyish-tinged. Legs pale whitish-ochreous, anterior pair dark fuscous. Forewings elongate, very narrow, broadest near base, long-pointed; deep ochreous-yellow; a rather broad ashy-grey streak along costa from base to near apex; a short indistinct streak on fold at $\frac{1}{4}$, an irregular spot in disc before middle, and a short irregular longitudinal streak in disc about $\frac{3}{4}$, fuscous or grey, tending to be variously suffused together or with costal streak, or frequently more or less wholly obsolete: cilia light grey. Hindwings and cilia light grey.

Auckland, Taranaki, Palmerston, and Wellington; common amongst forest, from January to March. It is a variable species, but always recognisable by the deep ochreous-yellow ground-colour.

21. *Stath. campylocha*, n. sp.

♂♀. 12–14mm. Head and thorax whitish-ochreous, somewhat metallic-shining. Palpi and antennæ pale whitish-ochreous. Abdomen grey. Legs whitish-ochreous, greyish-tinged, anterior pair dark grey, posterior tibiæ with dark-grey scales at origin of spurs. Forewings elongate, very narrow,

broadest near base, long-pointed; whitish-ochreous; an ochreous-fuscous or dark fuscous streak along costa from base to ¾, sometimes almost obsolete; an ochreous-fuscous or dark fuscous broadly V-shaped mark before middle, more or less suffused, variable in thickness, its angle resting on inner margin, extremities nearly reaching costa; a longitudinal line in posterior half of disc, a spot at apex, and an elongate spot at anal angle ochreous-fuscous or ochreous, sometimes partially connected: cilia grey. Hindwings rather dark grey; cilia grey.

Wellington and Dunedin; five specimens in January and February, amongst forest. Also variable; in addition to the conspicuous dark V-shaped mark of the forewings, the darker grey hindwings and grey abdomen are good distinguishing characters.

22. *Stath. skelloni*, Butl.

(*Boocara skelloni*, Butl., "Cist. Ent.," ii., 562.)

♂ ♀. 12–15mm. Head, palpi, and antennæ pale whitish-ochreous. Thorax whitish-ochreous. Abdomen pale whitish-ochreous, greyish-tinged. Legs pale whitish-ochreous, anterior pair infuscated, apex of posterior tibiæ grey. Forewings elongate, very narrow, broadest near base, long-pointed; whitish-ochreous, sometimes yellowish-tinged; markings grey, very variable, sometimes partially margined by an ochreous suffusion; normally an elongate spot on inner margin at ⅓, a second beneath costa in middle, a third in disc at ⅔, a fourth before apex, and a slender subcostal line from second spot to costa near apex, but these tend to be variously connected and confused; sometimes a streak along fold, or along anterior part of costa; rarely a dark ochreous-fuscous suffusion towards base of inner margin: cilia light grey, sometimes ochreous-tinged. Hindwings and cilia light grey.

Taranaki, Wellington, Blenheim, Nelson, Christchurch, Dunedin, Lake Wakatipu, and Invercargill; common amongst bush, from December to March, but seeming to disappear towards the north. Butler failed to recognise the genus; but it is fortunately unnecessary to consider how to treat his grotesquely solecistic generic name.

23. *Stath. epichlora*, n. sp.

♀. 9–11mm. Head, palpi, antennæ, thorax, abdomen, and legs whitish; anterior legs blackish in front, posterior tibiæ with a sharp black apical ring of scales, preceded above by some grey hairs. Forewings elongate, very narrow, broadest near base, long-pointed; whitish, more or less mixed with ochreous or grey in disc; markings rather dark fuscous, but cloudy and ill-defined; a small spot on inner margin at ⅓, a second more conspicuous on inner margin beyond middle, and

an angulated fascia-like spot towards apex: cilia whitish-grey. Hindwings and cilia whitish-grey.

Auckland, Wellington, and the Otira River (1,500ft.); six specimens amongst forest, in December and January. A distinct but inconspicuous species.

Calicotis, n. g.

Head smooth; ocelli present; tongue rudimentary. Antennæ $\frac{3}{4}$, in male rather stout, filiform, basal joint broadly dilated, excavated beneath to form an eyecap, rough-scaled on posterior edge, without pecten. Labial palpi long, curved, ascending, smooth-scaled, terminal joint shorter than second, acute. Maxillary palpi obsolete. Middle tarsi with long projecting spines at apex of two basal joints; posterior tibiæ clothed with dense long rough hairs above and beneath, posterior tarsi with whorls of long projecting spines at apex of all joints. Forewings with vein 1 simple, 2 and 3 absent, 4 from angle of cell, 7 and 8 stalked, 7 to costa, 11 from $\frac{4}{5}$ of cell. Hindwings $\frac{1}{2}$, linear, cilia 7; vein 4 absent, cell open between 3 and 6, 5 free rising from base, 6 and 7 from a point.

Allied to *Stathmopoda*, but differing especially by the greatly dilated and excavated basal joint of antennæ, and by the entire absence of the long antennal ciliations. In repose the imago bends the posterior legs to form an angular arch, and extends them horizontally at right angles to the body. The habits of the larva are known, and interesting.

24. *Cal. crucifera*, n. sp.

♂ ♀. 9–12mm. Head, palpi, antennæ, thorax, abdomen, and legs very pale whitish-ochreous; terminal joint of palpi with a dark fuscous line on outer edge; anterior legs suffused with blackish in front, posterior legs spotted with black on apex of joints. Forewings elongate, very narrow, broadest near base, long-pointed; ochreous-whitish, more or less irregularly suffused or blotched with ochreous; a small cloudy dark fuscous spot on inner margin near base, and another on costa slightly before middle, both in female sometimes almost obsolete; an apical black dot: cilia grey-whitish. Hindwings whitish-grey; cilia grey-whitish.

Larva 16-legged, moderately stout, cylindrical, active; whitish flesh-colour, or whitish; head pale whitish-brown. Feeds on *Platycerium grande* (a large parasitic fern, growing on tree-trunks), burrowing amongst the ripe fructification beneath the fronds, forming galleries of loose refuse; found in March.

Taranaki and Palmerston, in February and March; common amongst its food. The species occurs also plentifully in the Botanical Gardens at Sydney, but I have not yet met

with it in native forest in Australia, and it is therefore at least possible that it was introduced into Sydney with ferns from New Zealand. The food-plant is, however, considered native in both countries.

THYLACOSCELES, n. g.

Head smooth; ocelli present; tongue developed. Antennæ $\frac{5}{6}$, in male stout, very shortly ciliated ($\frac{1}{3}$), basal joint moderate, without pecten. Labial palpi very long, slender, recurved, smooth-scaled, terminal joint as long as second, acute. Maxillary palpi obsolete. Posterior tibiæ with long hairs above, with a large dense triangular tuft of long scales covering terminal half above, tarsi with long projecting spines at apex of two basal joints. Forewings with vein 1 furcate, 2 from $\frac{2}{3}$ of cell, 3 from angle, 7 to costa, 11 from $\frac{3}{4}$ of cell. Hindwings $\frac{1}{2}$, linear-lanceolate, cilia 6; veins 2, 3, 4, 5 tolerably parallel, 6 and 7 approximated at base.

Allied to *Stathmopoda;* sufficiently distinguished by the very short antennal ciliations, and peculiar tuft of tibiæ, apart from the neuration; the latter, I believe, I have made out correctly, but cannot be sure on my single specimen, which proved difficult of examination. In repose the imago holds the posterior legs so as to project behind and rest on the surface, but with the tibiæ and tarsi bent so as to form an erect triangle with the surface on which it rests; hence with much the superficial appearance of the hindlegs of a grasshopper.

25. *Thyl. acridomima*, n. sp.

♂. 11mm. Head and palpi light yellowish-ochreous. Antennæ whitish-fuscous, base yellowish. Thorax fuscous. Abdomen grey. Anterior legs dark fuscous; middle legs ochreous-yellowish; posterior legs ochreous-whitish, tibiæ with a black apical ring, and tuft of posterior half dark grey. Forewings elongate, very narrow, broadest near base, long-pointed; fuscous, somewhat unevenly shaded, but without markings: cilia light fuscous. Hindwings fuscous-grey; cilia light fuscous.

Wellington; one specimen in January.

ZAPYRASTRA, n. g.

Head smooth; ocelli present; tongue developed. Antennæ $\frac{4}{5}$, in male subserrate, slightly thickened towards apex, basal joint elongate, obconical, without pecten. Labial palpi moderate, curved, ascending, slender, smooth, terminal joint shorter than second, acute. Maxillary palpi rudimentary. Posterior tibiæ thinly haired above on basal half and at apex. Forewings with vein 1 furcate, 2 from rather near angle of

cell, 7 and 8 stalked, 7 to costa, 10 from near angle, 11 absent. Hindwings ½, linear-lanceolate, cilia 5; veins 2, 3, 4 parallel, cell open between 4 and 5, 5 and 6 stalked, 6 to close below apex, 7 approximated to 6 at base.

Allied to the European genus *Chrysoclista*, from which it differs principally in the neuration of forewings. The group of *Laverna*, to which it belongs, although extensively represented in Australia, has probably no truly indigenous representatives in New Zealand; the present species, common to both countries, is in all probability really Australian, and has found its way over within comparatively recent times.

26. *Zap. calliphana*, n. sp.

♂ ♀. 5–8mm. Head, palpi, antennæ, thorax, abdomen, and legs dark shining bronze, face whitish-bronze, legs spotted with white. Forewings lanceolate; bright dark golden-bronze; markings pale violet-golden-metallic; a fascia near base, often ill-defined; a nearly perpendicular fascia before middle; a dot in disc beyond middle, beneath which is a black dot or small spot on fold; an inwardly-oblique fascia at ¾; a small spot on anal angle; a streak along hindmargin from apex; a triangular snow-white spot on costa near apex: cilia fuscous-grey, round apex with two blackish lines, and a minute white dot above apex. Hindwings dark fuscous; cilia fuscous-grey.

Christchurch and the Bealey River; rather common from December to February, frequenting *Leptospermum*, on which the larva must certainly feed. The species is common also in New South Wales and Tasmania, frequenting the same plant, from September to April.

Limnœcia, Stt.

Head smooth; ocelli absent; tongue developed. Antennæ ⅘, in male serrate, moderately ciliated (1), basal joint very elongate, dilated towards apex, with one or two hair-scales at base. Labial palpi very long, recurved, second joint thickened with appressed scales, terminal joint longer than second, acute. Maxillary palpi rudimentary. Thorax in male with a long fine curved pencil of hairs from each side beneath, directed backwards. Posterior tibiæ clothed with long hairs above. Forewings with vein 1 furcate, 2 from ⅘ of cell, 7 and 8 stalked, 7 to costa, 11 from before middle of cell. Hindwings ⅘, elongate-lanceolate, cilia 2; veins all separate and tolerably parallel.

Stainton was undoubtedly mistaken in reuniting this genus to *Laverna*, to which it is by no means closely allied, differing in several essential points.

27. *Limn. phragmitella*, Stt.

♂♀. 15–21mm. Head and thorax pale ochreous. Palpi whitish-ochreous, terminal joint with a longitudinal dark fuscous line. Forewings elongate, very narrow, long-pointed; whitish-ochreous, brownish-tinged; a round dark fuscous dot in disc before middle, and a second at ⅔, tending to be ringed with ochreous-whitish, and connected by an obscure streak of ochreous-whitish scales somewhat mixed with fuscous; beyond the second dot is generally a small fuscous spot: cilia whitish-ochreous. Hindwings pale grey, ochreous-tinged; cilia whitish-ochreous.

Larva yellow-whitish, with five brownish longitudinal lines; feeding in seedheads of *Typha angustifolia*, burrowing amongst the seeds, and causing the down to hang out in loose masses, exactly in the manner of *Scieropepla typhicola.*

Hamilton; one specimen in January, amongst the swamps of the Waikato. I have also taken it in New South Wales. The species occurs in Central Europe, but is not very widely known, probably owing to the retired habits of the imago. My specimens are the only ones taken outside Europe; yet, as it is hardly conceivable that the species should have been artificially introduced, and as the *Typha* is thought to be indigenous in suitable localities all round the world, I conjecture that the insect may be truly cosmopolitan. The light down of the seedheads, carrying the seeds of the plant and the ova of the insect, must be exceedingly susceptible of dissemination by the wind.

Syntomactis, n. g.

Head smooth; ocelli absent; tongue developed. Antennæ ⅘, in male serrate, pubescent, basal joint very elongate, with pecten. Labial palpi moderately long, curved, ascending, second joint with loose rough scales beneath towards apex, terminal joint as long as second, slightly roughened anteriorly, acute. Maxillary palpi very short, appressed to tongue. Thorax in male with some very long fine hairs beneath from posterior extremity. Posterior tibiæ clothed with long hairs above. Forewings with vein 1 furcate, 2 from angle of cell, 5 and 6 out of 7, 7 to costa, 8 out of 7 before 6, 11 from middle. Hindwings ½, linear-lanceolate, cilia 6; veins 2, 3, 4 parallel, 5 from a point with 6, 6 and 7 stalked.

Allied to the group of *Laverna*, but not very closely approaching any particular genus.

28. *Synt. deamatella*, Walk.

(*Gelechia deamatella*, Walk., 654.)

♂♀. 11–12mm. Head ochreous-white. Palpi white, second joint with basal half black, and apical and subapical ochreous rings, terminal joint with basal half black. Antennæ whitish,

obscurely ringed with blackish. Thorax white, or whitish-ochreous. Abdomen pale yellowish-ochreous, posteriorly greyer. Legs blackish, ringed with ochreous-white. Forewings very elongate, narrow, long-pointed; greyish-ochreous, coarsely and irregularly irrorated with dark fuscous; markings white, tending to be margined by a black suffusion; a triangular spot on costa before ⅓, its apex sometimes almost reaching inner margin; an irregular somewhat oblique blotch beyond middle, touching costa anteriorly, and almost reaching inner margin; a small ill-defined, irregular, transverse spot near apex, most distinct on costa: cilia pale ochreous-greyish, round apex somewhat mixed with fuscous. Hindwings grey; cilia pale ochreous-grey.

Christchurch and Invercargill in December, February, and March; six specimens, amongst bush.

Proterocosma, Meyr.

Head smooth; ocelli present or absent; tongue developed. Antennæ ⅘ to 1, in male serrate, pubescent or simple; basal joint elongate, with pecten. Labial palpi very long, recurved, smooth, slender, terminal joint longer than second, acute. Maxillary palpi rudimentary. Posterior tibiæ clothed with hairs above. Forewings with vein 1 furcate, 2 from ⅘ of cell, 5 sometimes out of 7, 6 out of 7 or absent, 7 to costa, 8 out of 7, 11 from before middle. Hindwings about ½, linear-lanceolate, cilia 3 to 6; veins 2, 3, 4 parallel, 5 approximated to 4, 6 and 7 from a point, or stalked, or rarely coincident.

This interesting genus, which is rather an old type of the family, and indicates the origin of some more widely-distributed forms, is rather extensively distributed in Australia, and I have also described several species from the South Pacific islands. Of the three New Zealand species, the first two are endemic, but markedly allied to Australian forms, the third is widely distributed in Australia.

1.	Forewings with clear white lines	*apparitella.*
	" without clear white lines	2.
2.	Forewings with irregular white markings, irrorated with black	*allotricha.*
	Forewings with defined round black dots ..	*anarithma.*

29. *Prot. apparitella*, Walk.

(*Gelechia apparitella*, Walk., 1,027.)

♂ ♀. 9–13mm. Head and thorax golden-ochreous, face white, eyes crimson. Palpi ochreous, more or less suffused with white, terminal joint white with anterior edge and often apex black. Antennæ white, ringed with black. Abdomen whitish-ochreous. Legs whitish, banded with dark fuscous, posterior pair pale whitish-ochreous. Forewings elongate, very narrow, long-pointed; vein 5 separate, 6 present; golden-

ochreous, paler towards costa posteriorly; markings snow-white, finely black-margined; a very slender median line from base to $\frac{1}{4}$; a slender oblique line from costa at $\frac{1}{5}$, terminating in a moderate triangular spot on inner margin before middle, which is either wholly white, or white with an ochreous centre, or wholly ochreous and scarcely paler than ground-colour; a line from $\frac{3}{5}$ of costa almost perpendicularly half across wing, thence abruptly rectangularly bent outwards to middle of disc, and again rectangularly bent to inner margin; a fine, extremely oblique line from middle of costa to disc at $\frac{3}{4}$, thence acutely angulated to anal angle, sinuate inwards beneath costa, connected with preceding line on costa by a fine white line, and on inner margin by a streak which is either white, or ochreous hardly paler than ground-colour; a whitish-ochreous or white, posteriorly black-margined, mark on costa at $\frac{4}{5}$, whence proceeds a black sometimes ill-defined line to apex; sometimes an irregular short white streak along hindmargin to apex: cilia light greyish-ochreous, round apex more golden-ochreous, with a black dot at base on apex. Hindwings with veins 6 and 7 stalked; costa in male with long loose hairs at base; grey; cilia light ochreous-greyish.

Auckland and Wellington; common amongst forest, in December and January.

30. *Prot. aëllotricha*, n. sp.

♂ ♀. 10–12mm. Head and thorax reddish-ochreous; face ochreous-whitish. Palpi white, second joint with three ochreous rings, terminal joint with three black rings. Antennæ white, ringed with black. Abdomen grey, towards base pale-ochreous. Legs whitish, banded with blackish. Forewings elongate, very narrow, long-pointed; vein 5 separate, 6 present; reddish-ochreous, tending to become whitish-ochreous round markings and towards base of inner margin; markings ochreous-white, closely irrorated with black; an irregular oblique fascia from $\frac{1}{4}$ of costa, not reaching inner margin, emitting a short streak from posterior edge above middle; an irregular somewhat 8-shaped spot in middle of disc, from upper part of which proceeds an irregular streak to costa before apex; an irregular ochreous-whitish streak along hindmargin from apex to anal angle; a black apical dot: cilia light ochreous-greyish, round apex reddish-ochreous, with a blackish basal line and two blackish apical hooks. Hindwings with veins 6 and 7 stalked; grey; cilia pale-grey, ochreous-tinged.

Hamilton; two specimens in January.

31. *Prot. anarithma*, n. sp.

♂ ♀. 7–10mm. Head and thorax brownish-ochreous, face ochreous-whitish. Palpi ochreous-whitish, second joint with

basal half and a subapical ring suffusedly irrorated with black, terminal joint irrorated with dark fuscous. Antennæ whitish-ochreous, ringed with dark fuscous. Abdomen grey-whitish, or grey. Legs dark grey, suffusedly ringed with whitish. Forewings lanceolate; vein 5 separate, 6 present; brownish-ochreous, sometimes more or less sprinkled with dark fuscous; a black dot on base of costa, sometimes obsolete, a second on costa near base, a third in disc beneath second, a fourth on base of inner margin, often obsolete, a fifth in disc before middle, a sixth on fold rather obliquely beyond fifth, and a seventh in disc at $\frac{3}{4}$; generally two small indistinct whitish-ochreous spots on costa and inner margin opposite seventh dot: cilia light grey, darker round apex. Hindwings with veins 6 and 7 from a point; grey; cilia light-grey.

Taranaki, Palmerston, Napier, and Masterton; from January to March, in some places exceedingly plentiful, but apparently not found everywhere. Around Taranaki I found it swarming in grassy places; it has quite the habits of an *Elachista*, and is probably a grass-feeder. It is very widely-distributed through Australia from east to west, but there also is local, and abundant in some places only.

Elachista, Stt.

Head smooth; ocelli present; tongue developed. Antennæ $\frac{3}{4}$, in male simple, filiform or serrulate, basal joint moderate, with or without pecten. Labial palpi long, recurved, slender, smooth-scaled, terminal joint shorter than second, acute. Maxillary palpi obsolete. Posterior tibiæ clothed with long hairs above and beneath. Forewings with vein 1 simple, 2 from angle of cell, 4 sometimes absent, 5 absent, 6 out of 7, 7 to costa, 8 out of 7 or absent, 9 approximated to or from point with or out of 7, 11 from middle. Hindwings about $\frac{1}{2}$, narrow lanceolate, cilia 3 to 5; vein 4 sometimes absent, 5 absent, cell sometimes open below 6, 6 and 7 stalked.

A genus of considerable extent, and probably cosmopolitan, but from the obscurity of the species hitherto not much noticed outside Europe. Besides the seven New Zealand species, I have about fifteen Australian. All known larvæ of the genus mine in leaves of grasses or sedges. Wocke separates the species in which vein 4 of both wings is absent (it appears to change in both wings simultaneously) as a distinct genus, under the name *Pœciloptilia;* but, after careful consideration, this appears to me unnecessary: there is no other difference whatever, and, as I have remarked above, in this family the disappearance of a vein is not of great importance, and the neuration of many of its genera is liable to vary to that extent. I have therefore retained all in one genus, but used the character to separate it into sections.

1. Palpi wholly white or whitish	.. ..	2.
„ partly grey	.. ..	4.
2. Forewings irrorated with grey	.. ..	*exaula.*
„ not irrorated with grey	.. ..	3.
3. Head and thorax striped with brown and white		*thallophora.*
„ not striped with brown and white	.. .. ..	*helonoma.*
4. Terminal joint of palpi wholly white or whitish		5.
„ „ not wholly white or whitish	.. ..	6.
5. Forewings with obscure dark fuscous streaks in disc	.. ..	*ombrodoca.*
Forewings without obscure dark fuscous streaks in disc	.. ..	*gerasmia.*
6. Forewings dark grey	.. .. ..	*archæonoma.*
„ whitish-grey	.. .. ..	*melanura.*

§ A. Vein 4 of both wings present.

32. *Elach. melanura*, n. sp.

♂. 13mm. Head, palpi, antennæ, and thorax whitish-grey. Abdomen ochreous-whitish, with a dense black apical exsertible tuft. Legs dark fuscous, posterior pair ochreous-whitish. Forewings lanceolate; whitish-grey, somewhat irrorated with darker; an elongate black dot on fold before middle, a second in disc above middle, and a third in disc at $\frac{2}{3}$: cilia grey-whitish, with a spot of black scales at base round apex, and tips sprinkled with black. Hindwings and cilia pale whitish-grey.

Hamilton; one specimen in January. I have two specimens from Australia which closely resemble this, and which agree in possessing the characteristic and highly peculiar black anal tuft; but, as they differ considerably from the New Zealand specimen, and also from one another, in the position of the black dots on the forewings, I have not felt justified at present in uniting them, although I think it very probable that a longer series of specimens may prove this character to be variable.

33. *Elach. gerasmia*, n. sp.

♂ ♀. 9–14mm. Head whitish. Palpi grey, terminal joint and apex of second white. Antennæ grey. Thorax whitish-grey. Abdomen grey-whitish, anal tuft in male more or less ochreous-tinged. Legs dark grey, posterior pair grey-whitish. Forewings lanceolate; light grey or rarely grey-whitish; a black dot on fold in middle, and an elongate black dot in disc at $\frac{2}{3}$: cilia grey, with indications of two black lines for a short distance below apex. Hindwings and cilia grey.

Hamilton, Makatoku, and Invercargill; common in swampy places, in December, January, and March.

34. *Elach. thallophora*, n. sp.

♂♀. 8–15mm. Head ochreous-whitish, with a central longitudinal ochreous-brown stripe. Palpi white. Antennæ whitish-fuscous. Thorax brown, with an ochreous-white stripe on each side of back. Abdomen grey, anal tuft ochreous-whitish. Legs dark fuscous, posterior pair whitish. Forewings lanceolate; pearly white; an ochreous-brown longitudinal streak from base of costa, and another from base in middle, converging to a point in disc at ⅘, where they terminate; an ochreous-brown streak along inner margin from base to anal angle; in male these markings are thicker, darker, and more suffused, and posterior half of costa is also suffused with brown: cilia in male whitish-fuscous, in female ochreous-whitish, beneath anal angle fuscous-tinged. Hindwings grey; cilialight grey.

Christchurch (on sandhills) and Mount Arthur (4,000ft.), in January and March; locally abundant. The variation in size is noteworthy, some of the largest females being twice as large as the males. The species is a remarkably distinct one, but recalls *E. rufocinerea*, to which it has probably some real relationship.

§ B. Vein 4 of both wings absent.

35. *Elach. helonoma*, n. sp.

♂♀. 8–10mm. Head and thorax ochreous-whitish, sprinkled with ochreous. Palpi white. Antennæ fuscous. Abdomen grey-whitish, anal tuft ochreous-whitish. Legs dark fuscous, posterior pair ochreous-whitish. Forewings lanceolate; whitish, more or less irrorated with ochreous, especially on dorsal half; a slender ochreous-fuscous median longitudinal streak from near base to middle, and a second from above extremity of first to near apex; a fuscous dot beneath apex of first streak, sometimes obsolete; inner margin more or less obscurely brownish towards base: cilia grey-whitish. Hindwings pale grey; cilia grey-whitish.

Christchurch, on the Port Hills; in January and March, abundant amongst the tussock-grass, to which it appears attached.

36. *Elach. exaula*, n. sp.

♂. 9–10mm. Head and palpi ochreous-whitish. Antennæ fuscous. Thorax whitish-ochreous irrorated with grey. Abdomen grey, anal tuft whitish-ochreous. Legs dark grey, ringed with whitish, posterior tibiæ whitish. Forewings lanceolate; pale whitish-ochreous, irrorated with grey, more closely and suffusedly on costa, more yellowish-tinged in disc; a slender black median streak from near base to before middle; a black elongate dot in disc above middle, and a second, larger

and more distinctly elongate, below it; a slender black median streak from ⅔ to near apex: cilia light grey, round apex ochreous-whitish with a fine black line. Hindwings grey; cilia light grey.

Mount Arthur (4,000ft.); three specimens in January.

37. *Elach. ombrodoca*, n. sp.

♂ ♀. 6–9mm. Head grey-whitish, in male irrorated with dark grey. Palpi dark grey, terminal joint and apex of second whitish. Antennæ grey. Thorax grey-whitish, irrorated with dark grey. Abdomen grey, anal tuft ochreous-whitish. Legs dark grey, apex of joints whitish, posterior tibiæ ochreous-whitish. Forewings lanceolate; ochreous-whitish, in male densely irrorated throughout with dark grey, in female more sparsely; an indistinct slender dark fuscous streak along fold from near base to ⅓; a cloudy dark-grey spot beneath costa slightly before middle, and another larger and more blackish obliquely beyond it near inner margin; preceding these are faint indications of an oblique paler fascia, more distinct in female; an indistinct short longitudinal dark fuscous streak in disc about ⅔; slightly beyond this are very faint indications of two paler marginal spots, appearing to form an angulated fascia: cilia whitish-grey, ochreous-tinged, round apex more ochreous-whitish with a fine black line. Hindwings grey; cilia light grey.

Christchurch, Dunedin, and Invercargill; in August and September, and from February to April, very common in waste grassy places, as by roadsides.

38. *Elach. archæonoma*, n. sp.

♂ ♀. 6–8mm. Head, palpi, and thorax whitish irrorated with dark grey. Antennæ grey. Abdomen grey, anal tuft in male grey, in female ochreous-whitish. Legs dark grey, ringed with whitish. Forewings lanceolate; dark grey, irrorated with whitish; basal area in female distinctly paler; an oblique pale fascia before the middle, in male very obscure and indistinct, in female white and conspicuous; beyond this is a more or less defined blackish suffusion, tending to form two separate spots, lower more marked; indications of a short longitudinal dark fuscous streak in disc about ⅔; in female two conspicuous white opposite almost connected spots beyond ⅔, in male not traceable: cilia grey, with a fine black line round apex, in female with a distinct white apical spot. Hindwings and cilia grey.

Auckland, Nelson, Wellington, and Dunedin; common in grassy places by roadsides, in December and January. The very considerable dissimilarity between the sexes is the same as occurs in some European species, as *E. obscurella*.

Batrachedra, Stt.

Head smooth; ocelli present; tongue developed. Antennæ $\frac{4}{5}$, in male filiform, simple, basal joint short, without pecten. Labial palpi moderately long, recurved, second joint with scales more or less slightly projecting angularly in front at apex, sometimes produced into a short dense tuft, terminal joint shorter than second, somewhat roughened with scales anteriorly, acute. Maxillary palpi very short, drooping. Posterior tibiæ with short tolerably-appressed hairs above. Forewings with vein 1 obsoletely furcate, 2 from near angle of cell, 3 absent, 6 and 7 sometimes stalked, 7 to costa, 8 absent, 11 from near middle. Hindwings $\frac{1}{2}$, linear-lanceolate or linear, cilia 5–8; 2 and 3 sometimes absent, cell open between 4 and 5, 5 approximated to or out of 6 or absent, 6 and 7 approximated.

A genus containing at present two European species, probably two or three North American, about twenty Australian, and three from New Zealand. There is considerable variation in the scaling of the second joint of palpi, which sometimes forms a well-marked projecting tuft in front, whilst more commonly it appears only as a very slight projection, but these are essentially modifications of the same type, and are connected by such intermediate gradations that no separation is possible; and also in the neuration of the hindwings, where some of the veins are liable to disappear, but here also every gradation is found. The species are very similar in appearance and habit; probably most of the larvæ feed on the seeds of rush *(Juncus)*.

1.	Forewings white	.. *psithyra*.
	„ pale ochreous	.. 2.
2.	Palpi with second joint tufted in front..	.. *eucola*.
	„ „ not tufted in front	.. *arenosella*.

39. *Batr. eucola*, n. sp.

♂. 19mm. Head and antennæ whitish-ochreous. Palpi whitish-ochreous, terminal joint and apex of second more brownish, second joint with scales projecting in front into an angular tuft. Thorax pale brownish-ochreous. Abdomen whitish-ochreous. Legs dark fuscous, apex of joints whitish-ochreous. Forewings elongate, very narrow, parallel-sided, long-pointed; veins 6 and 7 stalked; whitish-ochreous, somewhat sprinkled with brownish-ochreous, towards costa broadly suffused with brownish-ochreous, costal edge fuscous towards base; a dark fuscous dot in disc before middle, a second on fold obliquely before first, and a third, larger and somewhat transverse, in disc before $\frac{3}{4}$: cilia whitish-ochreous, beneath anal angle greyish-tinged, on costa marked with three dark fuscous dots, with indications of two dark fuscous lines at

apex only. Hindwings with all veins present; grey, slightly ochreous-tinged; cilia light grey, slightly ochreous-tinged, on costa whitish-ochreous.

Bealey River; one specimen in January. This is the largest species of the whole genus known, with the most pronounced tuft of palpi, and the full neuration of hindwings.

40. *Batr. arenosella*, Walk.

(*Gracilaria arenosella*, Walk., 857.)

♂ ♀. 11–14mm. Head and thorax whitish-ochreous. Palpi whitish-ochreous, apex of second joint blackish, scales slightly projecting, terminal joint more whitish, with sub-median and apical black rings. Antennæ whitish-ochreous, indistinctly ringed with fuscous, towards apex with three or four broader fuscous bands. Abdomen ochreous-grey-whitish. Legs dark fuscous, ringed with whitish, posterior tibiæ ochreous-whitish irrorated with dark fuscous. Forewings elongate, very narrow, long-pointed; veins 6 and 7 separate; pale yellow-ochreous, finely sprinkled with dark fuscous; a dark fuscous dot in disc before $\frac{1}{3}$, and another at $\frac{2}{3}$, occasionally obsolete: cilia pale grey, on costa whitish-ochreous, sharply divided at apex. Hindwings with veins 2, 3, and 5 absent; pale grey; cilia pale grey.

Larva feeds amongst seeds of *Juncus*, joining them together with a slight web, in August: pupa very slender, in a cocoon amongst the seeds.

Palmerston, Wellington, and Christchurch; common from January to March. Also, generally distributed in east and south Australia, which is doubtless its place of origin. The species is closely allied in every way to the European *B. pinicolella*.

41. *Batr. psithyra*, n. sp.

♂. 7–10mm. Head, thorax, and abdomen pearly white. Palpi white, second joint with a blackish sub-apical ring, scales slightly projecting, terminal joint with a blackish basal ring. Antennæ white, indistinctly ringed with pale fuscous. Legs white, indistinctly banded with fuscous. Forewings elongate, very narrow, long-pointed; veins 6 and 7 stalked; white, more or less sprinkled with fuscous; a dark fuscous elongate dot in disc before middle, a second very obliquely before it on fold, and a third in disc beyond $\frac{2}{3}$; a sharply-marked black apical dot: cilia whitish, with a black line opposite apex only. Hindwings with veins 2, 3, and 5 absent; whitish; cilia whitish.

Auckland, Hamilton, Wellington, Nelson, and Invercargill; ten specimens, in December and January.

GRACILARIADÆ.

Head smooth, or rough on crown (not in New Zealand genera). Antennæ nearly as long as forewings or longer, simple. Maxillary palpi developed. Labial palpi slender, ascending. Forewings with vein 1 simple, 11 from before middle of cell. Hindwings lanceolate or linear, cell open. Larva 14-legged.

The New Zealand species of this family have apparently no near specific relationship to the Australian; possibly they have more affinity with the South American, which are insufficiently known.

1. Palpi with second joint tufted beneath .. *Coriscium.*
   " " not tufted beneath 2.
2. Posterior tibiæ rough-haired above .. *Conopomorpha.*
   " " smooth above .. .. *Gracilaria.*

Gracilaria, Z.

Head smooth; ocelli absent or rarely present; tongue developed. Antennæ 1 or over 1, in male filiform, slender, basal joint moderate, without pecten. Labial palpi long, curved, ascending, smooth-scaled, second joint sometimes loosely scaled beneath towards apex, terminal joint almost as long as second, acute. Maxillary palpi moderately long, filiform, porrected. Middle tibiæ sometimes dilated with scales, posterior tibiæ smooth-scaled. Forewings with vein 1 simple, 2 from $\frac{4}{5}$, 3 sometimes absent, 4 and 5 often approximated, 7 to costa, 11 from before middle or near base, secondary cell sometimes well defined. Hindwings about $\frac{1}{2}$, lanceolate or linear-lanceolate, cilia 4–5; 3 sometimes absent, cell open between 4 and 5, 5 and 6 stalked, their stalk sometimes continued to base of wing, 7 from angle of cell, or rarely out of 6.

The larvæ are usually leaf-miners, or less commonly roll leaves into a peculiar conical chamber; but the only known New Zealand larva is exceptional in the genus, living in spun-up shoots like an ordinary *Tortrix* or *Gelechia.*

1. Forewings with costal half yellow .. .. *chrysitis.*
   " " " not yellow .. 2.
2. Forewings obliquely streaked with white and fuscous .. .. 3.
   Forewings not obliquely streaked with white and fuscous .. .. 4.
3. Palpi wholly white .. .. *leucocyma.*
   " with two black rings .. .. .. *aellomacha.*
4. Palpi with two black rings .. .. .. *æthalota.*
   " without two black rings .. .. 5.
5. Palpi with second joint whitish .. .. *linearis.*
   " " reddish-ochreous .. *chalcodelta.*

§ A. Vein 7 of hindwings from angle of cell.

42. *Grac. chrysitis*, Feld.

(*Gracilaria chrysitis*, Feld., pl. cxl.; *G. adelina*, Meyr., "Proc. Linn. Soc. N.S.W.," 1880, 142; *G. rutilans*, Butl., "Cist. Ent.," ii., 561.)

♂ ♀. 12–13mm. Head and thorax deep reddish-ochreous, violet-shining, face snow-white. Palpi reddish-ochreous, towards base white, terminal joint dark purplish-fuscous. Forewings deep reddish-ochreous, with coppery-violet reflections; a very broad pale metallic yellow costal band, its lower edge indented by a conical projection of ground-colour before middle, and a shorter one midway between this and base, both suffused with deep cobalt-blue; dorsal reddish-ochreous area marked on lower ⅔ with regular transverse strigulæ of deep cobalt-blue, appearing black in some lights. Hindwings rather dark grey.

Hamilton, Palmerston, and Christchurch; rather common amongst forest, in September, January, and March. This and the next two species are nearly related together.

43. *Grac. chalcodelta*, n. sp.

♂ ♀. 11–13mm. Head whitish-yellowish, more or less reddish-ochreous on crown. Palpi reddish-ochreous mixed with dark fuscous. Antennæ dark fuscous, ringed with whitish. Thorax reddish-ochreous. Abdomen whitish-grey. Legs purple-blackish, banded with white, middle tibiæ with large tuft of rough scales beneath, posterior tibiæ white. Forewings elongate, very narrow, long-pointed; reddish-ochreous, with purple gloss, with scattered blackish and yellow-whitish scales forming indications of obscure transverse strigulæ; costa and inner margin distinctly strigulated with black and pale yellowish; a pale brassy-yellow well-defined triangular patch on costa before middle, reaching about half across wing: cilia light grey, on costa and round apex reddish-ochreous, round apex mixed with blackish in several ill-defined lines. Hindwings and cilia light grey.

Whangarei, Auckland, Taranaki, Makatoku, Masterton; in December, February, and March, six specimens.

44. *Grac. linearis*, Butl.

(*Gracilaria linearis*, Butl., "Proc. Zool. Soc. Lond.," 1877, 406, pl. xliii., 16.)

♂ ♀. 13–14mm. Head and thorax reddish-ochreous, sometimes with a brassy gloss. Palpi whitish, terminal joint dark reddish-fuscous. Antennæ fuscous annulated with whitish. Abdomen ochreous-whitish or grey. Legs dark purplish-fuscous, banded with white, posterior tibiæ white. Forewings elongate, very narrow, long-pointed; more or less deep reddish-ochreous, with a brassy gloss; a hardly perceptibly paler

triangular patch on costa before middle; some scattered irregular blackish dots, mostly on posterior $\frac{2}{3}$ of fold, and in a longitudinal series in posterior half of disc: cilia light grey or ochreous-grey-whitish, round apex and on costa reddish-ochreous. Hindwings and cilia grey or ochreous-grey-whitish.

Var. *a*. Forewings suffused with dark purplish-fuscous, with a bright reddish-ochreous streak along inner margin.

Larva 14-legged, moderate, cylindrical, tapering at both ends; dull grey-greenish or grey-yellowish; dorsal darker; subdorsal broad, grey, or obsolete; head and plate on second segment dark fuscous. Feeds between spun-together shoots or leaves of *Coriaria ruscifolia*, *C. thymifolia*, and *C. angustissima*, in January.

Napier, Wellington, Arthur's Pass (3,000ft.), Christchurch, and Invercargill; from December to February, common. I bred the species in abundance from the larvæ; otherwise I could scarcely have credited the unusual larval habit.

45. *Grac. leucocyma*, n. sp.

♀. 9mm. Head and palpi white. Antennæ fuscous, beneath white. Thorax light grey. Abdomen whitish. Legs dark grey, ringed with white, posterior tibiæ white. Forewings elongate, very narrow, pointed; grey; markings snow-white; a rather broad irregular streak along inner margin from base to apex, interrupted before middle by a very oblique indistinct line of ground-colour; eight short more or less wedge-shaped streaks from costa, first from $\frac{1}{4}$, slenderly produced on costa towards base, first four outwardly oblique, remainder inwardly oblique, second and fourth reaching half across wing, the rest much shorter; a small irregular blackish apical dot, preceded by a white dot: cilia ochreous-grey-whitish, round apex whiter, with indications of two dark fuscous lines. Hindwings whitish-grey; cilia ochreous-grey-whitish.

Auckland, in December; one specimen. Although superficially resembling the following species, it is not really closely allied.

§ B. Vein 7 of hindwings out of 6.

46. *Grac. aëllomacha*, Meyr.

(*Gracilaria aëllomacha*, Meyr., "Proc. Linn. Soc. N.S.W.," 1880, 158.)

♂ ♀. 7–9mm. Head and palpi snow-white, palpi with apex of second joint and a subapical ring of terminal joint black. Thorax snow-white, with a small black spot on shoulder. Forewings snow-white; markings fuscous, irrorated with dark fuscous; a cloudy central longitudinal streak from near base to disc above anal angle, more or less obsolete towards base, connecting obscurely with about seven oblique

costal and about four oblique dorsal streaks (these vary somewhat); costal streaks usually alternately slender and thick; a fuscous apical spot: cilia grey, round apex white, with two dark fuscous lines and a black apical hook. Hindwings fuscous-grey, cilia paler.

Wellington and Christchurch, in September, January, and February; four specimens.

47. *Grac. æthalota*, Meyr.

(*Gracilaria æthalota*, Meyr., "Proc. Linn. Soc. N.S.W.," 1880, 148.)

♂. 9mm. Head and thorax fuscous-grey, face grey-whitish. Palpi whitish, apex of second joint and a subapical ring of terminal joint black. Forewings purplish-grey; margins faintly dotted with ochreous-whitish posteriorly: cilia grey, with obscure darker lines, and a white apical hook. Hindwings fuscous-grey, cilia paler.

Dunedin, in January; one specimen. Notwithstanding the different superficial appearance, this species is nearly allied to the preceding.

CORISCIUM, Z.

Characters of *Gracilaria*, but palpi with a loose projecting tuft of scales towards apex of second joint beneath, terminal joint usually longer than second.

48. *Cor. miniellum*, Feld.

(*Coriscium miniellum*, Feld., pl. cxl.; *Gracilaria ethela*, Meyr., "Proc. Linn. Soc. N.S.W.," 1880, 152.)

♂ ♀. 11–13mm. Head yellow on crown, crimson behind, face snow-white with two pale crimson spots. Palpi white, second joint crimson. Thorax yellow, anterior margin and a posterior spot crimson. Forewings pale yellow, deeper towards inner margin; a bright crimson undulating central streak from base to apex, sometimes margined with dark fuscous above, connected with inner margin by perpendicular bars near base and at $\frac{1}{3}$, $\frac{1}{2}$, and $\frac{3}{4}$, and connected with costa at and near base; a round crimson apical spot, containing a blackish spot towards costa, and a white triangular spot on inner margin: cilia yellow round apex, with a dark fuscous hook, crimson below apical spot, thence very pale crimson. Hindwings light crimson, cilia very pale crimson, on costa grey.

Var. *a*. All crimson colouring replaced by ochreous-brown, margined with dark fuscous.

Hamilton, Taranaki, and Palmerston; from January to March, locally plentiful, frequenting the depths of the forest. The variety occurs with the type, but much more scantily, in the proportion of about one in fifteen. I can offer no explanation of the magnificent colouring of this species, which would

be extraordinary anywhere, but is singularly different from the usually sombre insects of New Zealand.

Conopomorpha, Meyr.

Vein 11 of forewings should have been given as present, from near base of cell. The generic characters have been given previously, and need not be repeated. The genus is distinguished from *Gracilaria* by the rough hairs of posterior tibiæ, the rough scaling of palpi, and the stalking of veins 3 and 4 of forewings.

49. *Con. cyanospila*, Meyr.

(*Conopomorpha cyanospila*, Meyr., "Trans. N.Z. Inst.," 1885, 183.)

I need not repeat here the details given under the above reference, to which I have nothing to add.

NEPTICULIDÆ.

Head rough-haired all over. Antennæ shorter than forewings, basal joint dilated to form an eyecap. Maxillary palpi developed. Hindwings lanceolate, cell open.

Probably this family should be included in the *Tineidæ*, to which it is closely allied, and from which it differs essentially only by the eyecap of the antennæ, not a very important point. At present I place them separate, until further consideration. The neuration of the known genera is of a very degraded type, and the species are amongst the smallest known *Lepidoptera*.

Nepticula, Z.

Head densely rough-haired; no ocelli; tongue absent. Antennæ $\frac{1}{3}$–$\frac{2}{5}$, in male simple, filiform, basal joint dilated and excavated beneath to form an eyecap. Labial palpi short, porrected, filiform or loosely scaled. Maxillary palpi moderately long, folded, filiform. Posterior tibiæ clothed with rough hairs above. Forewings with vein 1 obsoletely furcate, cell open between 2 and 6, 3, 4, 5 absent, 8 out of 7 or absent, 7 to costa, 9 absent, 11 from before middle. Hindwings $\frac{1}{3}$–$\frac{2}{3}$, lanceolate, cilia 3–4; veins 3, 4, 5 absent, cell open between 2 and 6, 6 and 7 apparently from a point.

The genus is probably cosmopolitan. In Europe and North America it is extensively developed, and I am acquainted with about twenty Australian species, some of which are very similar to the European. The larvæ have 18 rudimentary legs, and mine blotches or galleries in leaves; the Australian larvæ have the same habits as the European, but I have not observed signs of the larvæ in New Zealand. I have not properly examined the neuration of the following species, owing to the small size of the insects and the possession of only single specimens, but it appears normal.

1. Forewings with ground-colour whitish-ochreous ..	*propalæa.*
" " " pale grey ..	2.
2. Forewings with a pale suffused spot on costa posteriorly	*ogygia.*
" without pale spots	*tricentra.*

50. *Nept. tricentra*, n. sp.

♀. 6mm. Head and palpi grey-whitish. Antennæ, thorax, and abdomen grey. Legs dark grey, apex of joints whitish. Forewings lanceolate; pale grey, irrorated with darker; two or three small round black dots in an irregular longitudinal series towards middle of disc: cilia light grey. Hindwings and cilia light grey.

Christchurch, in March; one specimen.

51. *Nept. ogygia*, n. sp.

♂. 7mm. Head and palpi pale whitish-ochreous. Antennæ grey. Thorax and abdomen grey, sprinkled with ochreous-whitish. Legs dark grey, apex of joints whitish. Forewings lanceolate; pale grey, coarsely irrorated with black; an obscure cloudy ochreous-whitish suffusion towards costa at ⅘; an obscurely-indicated pale spot in disc before middle: cilia whitish-ochreous-grey, with an obscure line of dark scales round apex. Hindwings and cilia light grey.

Dunedin, in January; one specimen.

52. *Nept. propalæa*, n. sp.

♀. 7mm. Head, palpi, antennæ, and thorax whitish-ochreous. Abdomen light grey. Legs whitish-ochreous, anterior pair infuscated. Forewings lanceolate; whitish-ochreous, obscurely irrorated with brownish; a dark fuscous dot on fold at ¼, a second in disc before middle, and a third immediately before apex: cilia whitish-ochreous. Hindwings light grey; cilia whitish-ochreous-grey.

Arthur's Pass (3,000ft.), in January; one specimen.

The following additional notes on described species are made from specimens and information kindly sent to me by Mr. G. V. Hudson:—

Scoliodes cordalis, Dbld. Bred by Mr. Hudson from larvæ feeding in the berries of *Solanum aviculare*. This is a very interesting observation: the insect occurs in Celebes and Australia as well as in New Zealand, and its attachment to the widely-distributed genus *Solanum* explains the possibility of this.

Œcophora scholæa, Meyr. Bred by Mr. Hudson from a larva living in a silken tube underground beneath the roots of an old tree.

Œcophora politis, Meyr. Mr. Hudson informs me that this species rapidly becomes worn, and is difficult to obtain in

good condition; but he has sent me a fresh female, from which it is evident that the specimen I originally described is so much bleached that the description can hardly be applied to the fresh insect: I therefore redescribe it.

♀. 18–21mm. Head ochreous-yellowish. Palpi pale yellowish, second joint irrorated with fuscous on lower half. Antennæ fuscous. Thorax fuscous, apex of patagia and a posterior spot yellowish. Abdomen grey. Legs grey, posterior pair whitish-yellowish. Forewings elongate, slightly dilated, costa gently arched, apex round-pointed, hindmargin rather strongly oblique, slightly rounded; pale ochreous-yellowish, suffused with reddish-fuscous except towards costa anteriorly; a moderate well-defined clear ochreous-yellowish streak along inner margin from base to near anal angle, attenuated posteriorly, its upper margin triangularly indented before middle and edged by a darker reddish-fuscous suffusion; an obscure darker dot in disc at $\frac{2}{5}$, and a second at $\frac{3}{5}$, connected by an obscure pale line; faint indications of an angulated posterior darker line, indented above middle: cilia reddish-fuscous, irrorated with yellow-whitish. Hindwings and cilia grey.

It would not surprise me much to find that this was the other sex of *Œc. phegophylla.*

Mecyna deprivalis, Walk. I found the larva of this species commonly near Nelson, feeding on *Sophthora* (*Leguminosæ*), and give the description in full detail, to allow of comparison with the larvæ of closely-allied exotic species. Larva 16-legged, elongate, cylindrical, slightly tapering towards ends, with very long scattered whitish hairs; dull light bluish-green, segmental incisions more yellowish; an irregular raised white line above spiracles, becoming yellowish towards incisions, and obscurely margined with yellowish elsewhere above; segments 3–4 with one, 5–12 with two large raised black spots on each side of back, each spot marked with a white dot on each side, posterior spot of 12th segment white, black-centred and with a black rim; beneath anterior of these spots a large raised black spot on each segment; beneath this on segments 3–4 two moderate raised black spots, on segments 5–12 a black dot surrounded with whitish; on 12th segment a black dot on supraspiracular line, beneath which is another black dot surrounded with whitish, and enclosed beneath by a semi-circular black rim; spiracles black, surrounded by a circular whitish spot enclosed with a black rim; head testaceous; second segment grey-whitish, irregularly streaked and spotted with black; anal segment grey-whitish, dotted with black.

This larva is therefore conspicuously distinct from that of the Australian *M. polygonalis.*

ART. XV.—*On the Natural History of three Species of* Micro-Lepidoptera.

By G. V. HUDSON.

[*Read before the Wellington Philosophical Society, 25th July, 1888.*]

PLATE VIII.

IN most of the openings in the bush round Wellington may be seen a conspicuous-looking shrub, with very dark-green leaves and purple flowers, which in the autumn are replaced by large quantities of bright orange-coloured berries. Its popular name is, I believe, the New Zealand night-shade, and it is scientifically known as *Solanum aviculare.* About January a large number of these berries are full grown, although as yet quite green and unripe. It is in these that we must look for the larva of *Sceliodes cordalis*, Dbld., one of our most beautiful Pyrales, whose presence is readily detected by the large holes which it drills in the sides of the berries. When extracted from its burrow, this caterpillar is found to be very robust and of a light-reddish colour, paler beneath (pl. viii., fig. 2). Like most internal-feeding larvæ it is very sluggish, and seems quite helpless in the open.

The infected berries can easily be placed in a caterpillar-cage, and the enclosed larvæ will emerge when they are full grown and spin their small white cocoons on the sides of the cage, in which they are transformed into pupæ, the moths appearing about a month later.

This species is very partial to light, and hence frequently enters houses, but the best and most interesting method of procuring it is to rear it from the berries.

Our next species (*Heliostibes atychioides*, Meyr.) belongs to the *Tinidæ*, and its larva is found on the manuka (*Leptospermum*), twisting up the terminal shoots and devouring the leaves. It lives in a kind of tube which runs along one of the twigs, and is constructed of a mixture of leaves and silk. In colour this larva is dark brown, with the head and two first segments corneous, the rest of the body being ornamented with two black spots on the sides of each segment. The subdorsal and lateral lines are whitish, the former with an interrupted central black line (fig. 4). These caterpillars are rather difficult to extract from their habitations, as they are extremely active, darting either backwards or forwards with equal rapidity whichever end we happen to attack. When full grown, the insect closes up both ends of its tube, and constructs a small cocoon within, where it changes into a pupa from which the moth emerges in about three weeks' time, when it may be seen in great abundance, flying round the

manuka bushes towards evening during December and January. Specimens for the cabinet should always be reared from the larva, as the extreme activity of the perfect insect causes those captured in the open to be nearly always more or less injured (fig. 3).

Another species of Tortricidæ attached to the manuka is *Cacœcia excessana*, Walker. Its larva is very different from that of the preceding species, being of a light-green colour with a conspicuous yellow lateral line (fig. 6). During the spring months it joins one or two leaves together, feeding within, and is very active, leaving its retreat immediately when detected and lowering itself by a silken thread to the ground. The pupa is enclosed in a slight silken cocoon between two manuka leaves, and the moth appears about the end of November (fig. 5).

DESCRIPTION OF PLATE VIII.

Fig. 1. *Sceliodes cordalis.*
Fig. 2. „ larva.
Fig. 3. *Heliostibes atychioides.*
Fig. 4. „ larva.
Fig. 5. *Cacœcia excessana.*
Fig. 6. „ larva.

Art. XVI.—*On the Varieties of a common Moth* (Declana floccosa).

By G. V. Hudson.

[*Read before the Wellington Philosophical Society, 13th June, 1888.*]

Plate IX.

Seeing that the variation of *Lepidoptera* is attracting so much attention in England at the present time, more especially in its relation to the origin of species, it occurred to me that perhaps a few remarks on one of our moths (*Declana floccosa*) might be of some interest, especially as it seems not unlikely that we are here actually witnessing the gradual evolution of several distinct species from a single one of a very unstable character. I must, however, begin my remarks by stating that my information on the subject is at present very limited, the varieties of this insect which actually exist being doubtlessly very much more numerous than those which I have here figured and described. My chief object in writing this paper is not so much to give information, as to arouse a more active interest in a subject which I feel is far too comprehensive to be dealt with by myself alone.

With respect to the normal type of *Declana floccosa*, it is extremely hard to say much, as the several varieties do not contain any characters common to all of them, although, in many instances, the same markings can be recognised in several different forms. Thus we have nothing definite which can be said to form the basis of the species; our only course, therefore, is to take the simplest form, and regard that as the type. Pl. ix., figs. 7 and 8, represent this form. The following is a brief description: Front wings pale greyish white covered with numerous brownish-black streaks, exhibiting a slight concentration towards the tip of the wing, but varying much in intensity (compare figs. 7 and 8). Hindwings buff-coloured, shaded with pale brown towards their exterior margins. Next in order to this most simple form is the variety depicted at fig. 1, which exhibits several large round spots on the disc of the front wing, the minute streaks being decidedly concentrated on the hindmargin, and leaving the central portion of the wing considerably paler in colour than in the usual type. From this form we will now pass to an insect which was long known as *Declana nigrosparsa*, from the numerous black spots ornamenting its frontwings. It is a tolerably common and easily recognised variety (fig. 4).

Pl. ix., fig. 2, represents another very characteristic form of *D. floccosa*, distinguished from the type by the two conspicuous stripes which cross the forewings from the costa to the inner margin; one being situated near the thorax, and the other at about two-thirds of the distance towards the hindmargin, this latter being doubly curved. A further development of this form is drawn at fig. 5, where these two stripes are joined together, near the middle, by two lines running parallel with the hindmargin and costa of the wing. These two varieties were described under the name of *Declana junctilinea*, Mr. Meyrick having subsequently shown in his paper on the New Zealand Geometrina,* that they were inadmissible as species. A form combining the characters of *nigrosparsa* and *junctilinea* is shown at fig. 3, where we have both the curved lines and numerous black spots. Finally, we have a most conspicuous form (fig. 6), showing the greatest deviation from the original type, where the frontwings are entirely suffused with dark greyish-black, except two broad bands of the original light colour extending from the costa to the inner margin. The base and hindmargin of the posterior wings are also much suffused with dark-grey, leaving a broad ill-defined band of lighter colour across the middle of the wing.

Taking now a general view of these varieties it is manifestly impossible to regard them as constituting more than a

* "Trans. N.Z. Inst.," vol. xvi., p. 49.

single species, the numerous intermediate forms between the most marked of them rendering any attempts at subdivision completely futile. At the same time, I am led to believe that the larvæ of two of the most distinct types of variation—namely, *nigrosparsa* and *junctilinea*, exhibit considerable differences, although I have not yet reared a sufficient number to form any decided opinion on the subject. The larvæ of figs. 1, 4, 7, and 8, including the type and two varieties, feed on the New Zealand "currant" or "wineberry" (*Aristotelia racemosa*), and are of a dark reddish-brown colour, sometimes marbled with grey, closely resembling the twigs of the trees, and thus affording the caterpillars the usual protection from enemies. On the other hand, the larvæ of the vars. figs. 2 and 5 are light yellowish-brown with irregular darker markings, approximating closely to the stems of the manuka (*Leptospermum*), on which I have always found them. To any one interested in the development of species and inheritance of parental peculiarities, I think that this insect would be a most useful object for investigation. The fact that none of the varieties I have mentioned are confined to any particular sex would be most advantageous, as the experimentor could readily select a male and female of each conspicuous form from which he could obtain ova, and thus ascertain whether the well-marked peculiarities of the parents were inherited, or, in other words, whether there was any tendency to establish a permanent or specific character. Should it be found feasible to carry the observations through several generations of moths, I feel sure that the result obtained would have an important bearing on that much-vexed question, the origin of species.

Before concluding, I should like to point out how eminently suitable insects are for investigations of this character. In the first place their brief life enables the industrious observer to watch the same family of insects for several generations, an impossibility in the case of most other animals, while the conspicuous characters which distinguish the majority of the species, especially of the *Lepidoptera*, render any departure from the normal type at once perceptible. It is consequently somewhat surprising that they have been so little made use of, and it can only be attributed to that prejudice which unfortunately exists against the study of entomology even in the present day. Workers in most of the other branches of science are allowed to push their investigations far beyond the limits of direct usefulness, and are encouraged for their zeal and perseverance in so doing, whereas, in the case of the entomologist, unless the insects he is investigating are connected with agriculture or some other matter of equal importance, his labours are regarded as a mere waste of time. With respect to this idea, I can only say that, if the same utilitarian argu-

ment, which is applied so unsparingly to the entomologist, was used in every instance, I think that we should soon find that the majority of our most cherished studies and recreations might be readily dispensed with, and our lives consequently reduced to a condition of miserable monotony.

In England, I am happy to say, entomology is being more appreciated every day, the number of entomologists having increased enormously during the last twenty years. The Entomological Society of London alone consists of over three hundred members, while there are at least three other larger societies in London devoted almost exclusively to the same science. Surely a few inquiring minds in New Zealand will turn their attention to a study which offers a boundless field for investigation, coupled with inexpensiveness and plenty of out-of-door recreation.

DESCRIPTION OF PLATE IX.

Figs. 1–8. Varieties of *Declana floccosa*.

ART. XVII.—*A Description of a new and large Species of Orthopterous Insect of the Genus* Hemideina, *Walker*.

By W. COLENSO, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 12th Nov. 1888.*]

INSECTA.

ORDER. ORTHOPTERA.

Section. SALTATORIA.

Fam. LOCUSTIDÆ.

Genus **Hemideina.**

1. *H. nitens*, sp. nov., Col.

Female.—Piceous slightly convex, very glossy. Head small, dark (almost black), smooth with a stout keel between the eyes which is forked between antennæ; eyes very prominent, almond-shaped broad end above horns; antennæ (tips broken off) 1¾in. long, sub-moniliform, thickly pubescent, less so at base; clypeus blackish with a transverse brown band; labrum brown; labium black; palpi brown, fifth joint pubescent (also fourth, but less so), tip oval-spathulate; labial palpi slightly hairy, tip broadly-oblong. Prothorax (thoracic shield) much curved, 8 lines long, 4 lines wide, sub-rugulose, margined, anterior margin minutely ciliate, tawny brown with deeply indented rather coarse black markings (somewhat like

a broad full face with spreading horns); pronotum thickish, shield-like, margined, both it and mesothorax very dark; abdomen slightly compressed, clouded; abdominal segments darker below, increasing in hue towards tip; oviduct large, very thick at base; 10 lines long, curved, brown almost piceous. Legs stout; femora with 2 (sub 3) rows of black coarse oblong spots on each side; hind femora with a row of large black spines on lower margin (which is also black), and 2 minute ones inside of the row; the 4 anterior femora smooth; 4 anterior tibiæ with 5 black spines on each side; hind tibiæ very stout, black, with 4 long black spines on the outer side and 5 on the inner side, the third and fourth of the inner ones very long (¼in.) and sharp, and 2 small spines distant on the upper ridge; the posterior femora and tibiæ of about equal length—11 lines long; the anterior tibiæ with a pair of spines at the lower joint, upper side; the middle tibiæ with a single spine there; the posterior tibiæ with 2 pairs of spines ditto; tarsi piceous, almost black, slightly hairy; hairs short, patent; pulvilli thick, tumid, blackish, shining. Length of body 16 lines.

Hab. Found in firewood obtained from Forty-mile Bush, County of Waipawa, 1888; per Mr. A. Hamilton.

Obs. A peculiar species, differing from other described ones in its general very dark colour, extreme glossiness, having also a sub-metallic cupreous glow in several places, peculiar broad and coarse femoral markings, extra spines, remarkably thick and smooth tumid pulvilli, and hairy antennæ. I regret much the upper portions of the antennæ being wanting.

Art. XVIII.—*Notes on a peculiar Chrysalis of an unknown Species of Butterfly.*

By W. Colenso, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 8th October, 1888.*]

LEPIDOPTERA.

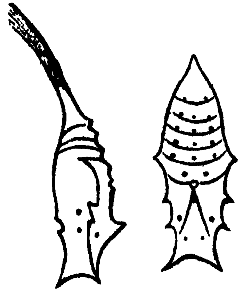
Section Rhopalocera.

Fam. NYMPHALIDÆ.

In the summer of 1887 (February), while botanising in the secluded forests and glens south of Dannevirke, I came upon a curious living chrysalis of a form hitherto unnoticed by me. It was attached to a branch of a species of *Galium*,* a large

* *Galium triloba*, Col., sp. nov., "Trans. N.Z. Institute," vol. xx., p. 192. (I have since detected this curious species growing profusely prostrate in large beds.)

prostrate plant, and, believing it to be new, I carefully secured it and brought it to Napier. As I expected it would shortly emerge in its imago state, I took accurate notes of this chrysalis in its fresh and living state, also a drawing of it, which I now give. I failed, however, in seeing the perfect insect, as the chrysalis never developed, but lost its original colours and decayed. I suppose it must have received some bruising in carriage, &c., although I took every possible care, having also formerly reared perfect insects of *Pyrameis gonerilla*, *Danais berenice*, *Dasypoda selenophora*, and others. It may be, however, only the pupa state of one of our known New Zealand butterflies, and also known to our colonial lepidopterists, who will in that case immediately recognise it from my description. It was certainly both very peculiar in shape and richly adorned in colours.



1. *2.*

1. Side view. 2. Front view. Chrysalis 10/12 inch long; slightly enlarged.

Description.—Chrysalis: Suspended by a stout web from its tail (none around the body), oblong (outline form), 10 lines long, 4 lines broad; somewhat sub-angular and rough, with many small muricate projections; colour olivaceous, smooth yet finely corrugated, glossy, with minute short wavy transverse black veins; the thorax and head having a semi-metallic glistening appearance, as if finely powdered with gold dust, with 6–8 large and more defined bright gold-like round spots on underside of thorax and head. Head broad, truncate and retuse almost bifid, acutely 2-horned at outer angles; sternum largely produced and very acute; tail produced, tip blackish, ½ line long, curved with a stout silken band 3 lines long; back flattish, with 4 small sharp points (2 pairs) near the centre and 2 larger on each side (edge of wings) nearly in the same lateral line, and 1 smaller on edge near fourth abdominal ring, and 5 blackish spiracle-like slits in a curved line from fourth abdominal ring to tip of tail; several fine longitudinal black lines running from each side of horn to the fifth and largest ring of abdomen, the outer pair of lines regularly studded their whole length with minute raised points; 3 large posterior black rings and 4 sub-obsolete anterior ones on abdomen underside; 8 pairs of acute points (feet) in 2 longitudinal lines, with 6 smaller central ones in a longitudinal line on abdominal rings; and a shining blackish disc with raised margin in centre of thorax under sternum.

Obs. This chrysalis somewhat resembles in form that of *Vanessa io*. Viewed in front its prominent sternum, &c., bears a likeness of the human face in ludicrous miniature. I

have ventured to classify it under the family of *Nymphalidæ*, from the fact of its only suspending itself by its tail. I am aware that the sub-family of *Libythæinæ* (Fam. *Erycinidæ*) does the same, but hitherto (as far as I know) none of this sub-family has been found in New Zealand.

Should any of our colonial lepidopterists, who may see this notice, be already acquainted with this form of pupa, and also with its perfect insect, I will thank him to inform me of it.

Art. XIX.—*A few Notes on the Economy and Habits of one of our largest and handsomest New Zealand Butterflies* (Pyrameis gonerilla).

By W. Colenso, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 8th October, 1888.*]

A few years ago, during my visits to our inland forests, I often had to pass close to a large shrubby *Urtica*,* and I invariably saw several of our large and handsome butterfly, *Pyrameis gonerilla*, hovering over it or settled on it. The shrub itself was in a sheltered sunny nook; and on one day in particular in early spring I counted no less than seventeen of these beautiful creatures at one time so engaged about that shrub, which none of them seemed desirous of leaving. It was a truly lovely scene which I well remember. Spring's woodland harbinger, the large-flowered clematis (*C. indivisa*) was pretty well developed overhead, swinging and displaying its long wreaths of peerless and pendulous virgin-white tresses from the lofty trees up which it had climbed when young; around were the many beautiful and stately tree-ferns, while below the ground was thickly carpeted with that neat close-growing bedding plant, with small and regularly-formed emerald foliage, *Pratia angulata*, expanding thankfully its myriads of white and blue star-like blossoms to the morning sun, and so drinking in life. The sun, too, was shining brightly down from the deep concave of the dark-blue sky, rarely flecked by a passing cloud; while the melodious tuis (*Prosthemadera novæ-zealandiæ*—parson-bird of the colonists), having had their breakfast of honey and nectar, were singing away joyfully and with good courage from their tiptop perches on the highest sprays, their dark and lustrous metallic plumage reflecting the rays of the sun. It is worthy of notice that this handsome and highly melodious bird always selects the highest and bare spray of a tall tree for its music-stool,

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* *U. ferox*, Forst., or a closely allied and undescribed species: *U. pungens*, MSS.

whence to pour forth its gushing notes; and this habit is more particularly observed by them soon after sunrise and at sunset, when to hear them of a fine summer's evening, when all is calm above and still below, is really ravishing. At such times the song by Capern, called "The Old Grey Thrush," has come forcibly to mind. As some of you may not know it, permit me to give part of the first stanza:—

> Of all the birds of tuneful note
> That warble o'er field and flood,
> O, give me the thrush with the speckled throat,
> The king of the singing wood!
> For see, he sits on the topmost twig
> To carol forth his glee,
> And none can dance a merrier jig,
> Or laugh more loud than he.

The whole of that song is apt (for the tui), and well worth repeating. To return, however:—altogether it was a pleasant time; all nature seemed in harmony; even the murmur of the rippling waters of the neighbouring brawling stream joined in unison, and conveyed a more soothing cadence than usual to the ear; and the briskly flitting butterflies above all appeared to be revelling in luxury, enjoying themselves and making the most of it. At such seasons snatches from the once popular song of fifty or sixty years ago, and long forgotten, "I'd be a butterfly, born in a bower," &c., would come rushing rapidly along through the dark lanes of encumbered memory into broad daylight. I remember well, standing entranced, as it were, for several minutes, contemplating and admiring the scene before me ere I could bring myself to resume my journey, and dive into the deeper and gloomy recesses of the forest.

That is a faint and brief description of what I saw there at that grand butterflies' ball and feast, in the early spring.

On a subsequent visit to that spot, one day in the autumn (28th April), on examining the *Urtica* shrub, I found 3 larvæ and 2 chrysalides of the *Pyrameis* on it: the larvæ feeding on its leaves, the pupæ hanging from it. The pupæ were suspended by a few tiny threads under a leaf, or within a leaf (or sometimes two leaves), the edges being very slightly drawn together with threads, but not closed up, remaining more than half open. In taking these rudimental insects, and gathering some of the leaves of the *Urtica* for the larvæ to feed on, I somehow got stung rather severely, in spite of all my care. I well remember the sharp permanent pain from the sting of that nettle, which lasted four days,* and was always increased through washing or wetting my hands.

* Since writing the above I find the same fact already recorded—"Fl. N.Z.," vol. i., p. 225, and "Handbook Fl. N.Z.," p. 252—I having forty years before experienced the same discomfort.

Four days after I again visited that spot and *Urtica* shrub for the last time that season (as I was to return to Napier the next day), and found 3 more larvæ and 2 chrysalides, and brought them all away. Arriving at Napier on the 2nd May, I placed the larvæ, with a quantity of fresh leaves, in a large white glass bottle; on the 4th, one of the larvæ had suspended itself to the (bored) cork of the bottle; on the 6th it cast its larva-skin and partly took up the chrysalis appearance, but was very wet at first; and on the 7th it assumed the true chrysalis aspect. On the 9th another of the larvæ hung itself to the cork, head downwards, and commenced its transformation. On the 11th one of the chrysalides dropped off from the cork; I had noticed that this one was smaller and of a lighter colour. On the 18th another of the larvæ entered into its chrysalis state, also attaching itself to the cork of the bottle.

On the 19th one of the chrysalides I had brought in that state from the forest burst, and the perfect insect emerged; but, owing to the shallowness of the glass in which these forest chrysalides were confined, one wing had got stuck fast to the side of the bottle in the process of emerging, and so became contracted and rigid when dry, like a little plaited epaulette; while the other wing, being free, had attained to its full size and shape; but the poor creature was sadly lop-sided. On the 21st another of the forest chrysalides split open, and the imago emerged—a beautiful sight,* once seen, never to be forgotten.

A thing of beauty is a joy for ever.

This was a fine and perfect specimen of this butterfly.

I regretted much those larvæ that entered into their pupa state here in Napier not emerging therefrom as perfect insects. I suspect this was owing either to their not having been fully fed down to the time of their entering into that state, or that they assumed it too early, and perhaps in an unhealthy state. As larvæ they were very voracious; it seemed as if they were always eating, night and day; so that my stock of *Urtica* leaves that had cost me so dearly were soon disposed of. On their being used up I tried the hungry creatures with several other leaves of Maori plants, but none would they touch. That shrub itself, though a large bushy and spreading one (about 5ft. high and several feet round), with several others, smaller ones, close by, almost always presented a sorry sight from their leaves being so gnawed and stripped; hence I had always some difficulty in procuring good specimens of it for drying and preserving. Those *Urtica* plants, however, recovered themselves throughout the winter, and were fully

* See the full description of similar emergence of *Danais berenice*, as witnessed by me ("Trans. N.Z. Inst.," vol. x., p. 279).

foliaged in early spring. I may also mention that, though the plant was said to be well known in that locality, I only met with it in one other spot, and that a single small specimen.

Seeing that the larvæ in their purely natural state always either suspend themselves to a twig or enwrap themselves in a leaf of the *Urtica*, it seemed strange that in no case did one of them so suspend itself to a stem in the bottle, but only and always to the cork (of course there were no leaves left). Was this done on account of more moving air there through the holes—such being requisite to dry their wings quickly when emerging—or to be in a position of more free space?

As I suppose both larva and pupa of this butterfly to be, like the perfect insect, well known, I do not attempt to describe them. The larva is a curious-looking object, from its being so very hairy; the hairs, too, are rather long, rigid, patent, dark-coloured, and produced in little bunches of irregular lengths.

Notwithstanding my partial failure in the rearing of them, a few plain facts in the natural economy of this butterfly seem to be substantiated: (1) That its larvæ feed on the leaves of *Urtica ?pungens*, Col., and are very voracious; (2) that on their entering into the chrysalis state they wrap themselves loosely in a leaf of the same plant, to which they are also fastened, or suspend beneath a leaf from its petiole or branchlet; (3) that the time occupied by the embryo insect in its chrysalis state is more than three weeks; (4) and that if it has not ample room for unfolding its wings on emerging from the chrysalis state they become stunted and useless, and then of course the insect is destitute of flight.

ADDENDUM.

I may here mention a similar case, as to contraction of wings under similar circumstances, that occurred a few years ago. In 1884, in a case of apples received from America (? California), I found a fine butterfly; one quite as large as our New Zealand *Pyrameis gonerilla*, if not much larger. It was but recently dead, and had evidently died in the case during the voyage; both of its wings were much crumpled and contracted, and its back chafed. Its prevailing colours were yellow and black (bluish-black) in broad streaks, the body the same, with broad yellow longitudinal stripes; very hairy at edges of wings in some parts; hairs long, yellow; and two large red spots on the wings; antennæ very dark, slender, naked; tips slightly clubbed; eyes very large and prominent. Being much crumpled, an only specimen, and tender, I only give its more striking aspect, as it requires to be softened and carefully laid out, before a strictly accurate description could be given. It is wholly unknown to me.

Art. XX.—*A few stray Notes on the New Zealand Owl,* Athene novæ-zealandiæ, *Gml.—Ruru and Koukou of the Maoris, and Morepork of the Settlers.*

By William Colenso, F.R.S., F.L.S., &c.

[*Read before the Hawke's Bay Philosophical Institute, 8th October, 1888.*]

When he heard the owls at midnight
Hooting, laughing in the forest,
"What is that?" he cried in terror;
"What is that," he said, "Nokomis?"
And the good Nokomis answered:
"That is but the owl and owlet,
Talking in their native language,
Talking, scolding at each other."
—*Hiawatha*, Canto III.

Several years ago—from 1844 to 1853—it was my lot to be often travelling on duty in the Wairarapa district. On one of those occasions I wished to reach the Maori village at the mouth of the Pahawa River on the east coast from the upper part of the Wairarapa Valley. In travelling thither we brought up for the night at the edge of a thicket, where my tent was pitched under a tree. My travelling companions and baggage-bearers, being weary with a long day's journey, were soon asleep, while I sat up reading, enjoying the stillness of the night, for it was a beautiful calm and moonlight one. Presently I heard a strange noise, or rather a succession of strange and peculiar unusual noises, such as I had never heard before. These were repeated over and over, in different and strange keys and semi-discordant tones, mixed with shrill hissing, and seemed as if coming from some creatures over my head; and at last, as I could not stand it any longer, I unlaced the door of my tent and got out. Keeping quiet, and concealing myself and looking up, I saw two owls on a rather bare extended horizontal branch of the tree only a few feet above me, and these were a pair, male and female, carrying on their courtship in the most strange manner imaginable. Such a grotesque sight I never saw before or since. The manner in which they acted; their pantomimic movements—half sedate and half funny—the gentleman owl advancing from his end of the branch with his head-feathers trimmed and set up *cap-à-pie*, and his wings let down, making with them a jarring noise as if he were a little turkey-cock, and at the same time uttering all manner of strange wooing sounds, high and low, short and long; and then the lady owl, on her part, retreating to the further end of the branch with measured step and slow, turning round, bridling herself up, hissing, and scornfully resenting the behaviour of the other; also, at times, uttering

strange noises, and adjusting her feathers to suit her scornful affected prude demeanour. Then the disappointed beau would slowly retire, making other peculiar sounds, to his end of the branch; when the lady would again come forward, very slowly and coquettingly, to her old position, and in a short time the gentleman owl would re-enact the solemn fun as before, only to be again served in the same kind of way. Such a mixture of strange sounds and grimaces, of pure bird *persiflage*, was unique and unusual. Words fail me fully to describe them; it was most ludicrous to behold them. The usual solemn gravity of the bird seems to have been abandoned or burlesqued. I watched them for about half an hour, when, as their play was still being carried on without alteration, I returned to my tent. I could not help thinking, from observing the extreme suitableness of that long horizontal half-denuded branch, with its bunch of leafy sprays at both ends, for their wooing and serenading,—and bearing in mind how confined the owl naturally is in its short flights, and prone to return to its haunts and perches,—that that branch was used as an old trysting-place by owls. I did laugh most heartily, though quietly, at this serio-comic performance; and whenever I have thought thereon, during these many subsequent years, it has always caused me to laugh outright.

I dare say some of my audience are acquainted with that charming book of Natural History, Gilbert White's "History of Selborne," so highly prized at home by our fathers. To those who know it, I need not say anything about it; but to those who do not, I would say—it is a most interesting book, written by an accomplished and loving naturalist, a keen and attentive observer of Nature in her manifold forms, but especially at home in his many and diverse observations on birds, as well as other animals: it is not a "dry" book. Mr. White was born at Selborne, in Hampshire, England, where, after his return from the University of Oxford, he quietly resided all his days, so spending an amiable, unambitious, and useful life, and died at an advanced age, much regretted. He steadily refused all church preferment, and during the last few years of his life officiated as curate of Selborne. His standard work has gone through several editions, and has always been highly esteemed by all lovers of Nature. Here I may be allowed to give a short sentence from its preface, written by himself exactly a hundred years ago (1788): "If the writer should at all appear to have induced any of his readers to pay a more ready attention to the wonders of the creation, too frequently overlooked as common occurrences, his purpose will be fully answered. But if he should not have been successful in any of these his intentions, yet there remains this consolation behind—that these his pursuits, by keeping

the body and mind employed, have, under Providence, contributed to much health and cheerfulness of spirits, even to old age."

Among his numerous scientific correspondents, one, who then stood prominently, was the celebrated working British naturalist Pennant, who was himself a correspondent of Linnæus. (Some of the works of Pennant are on our library-shelves: and his name is maintained and recorded among us in this country as that of a botanical genus, in our curious New Zealand forest-tree, *Pennantia*, so named by Forster.) And in an early letter from White to Pennant he makes a very similar complaint to that which I also drew your attention to in my "Presidential Address" four months ago. White says: "It has been my misfortune never to have had any neighbours whose studies have led them towards the pursuit of natural knowledge; so that, for want of a companion to quicken my industry and sharpen my attention, I have made but slender progress in a kind of information to which I have been attached from my childhood."

To return. On this subject of the variations in the hooting of owls, White has some shrewd remarks, bearing, I think, on this part of owl-conduct I have just narrated; though it does not appear that White, or his correspondents, had known the reason or cause of the variations they had noticed in the owl-dialect. White says: "A friend remarks that most of his owls hoot in B flat; but that one went almost half a note below A. The pipe he tried their notes by was a common half-crown pitch-pipe, such as masters use for the tuning of harpsichords; it was the common London pitch." And, again, White remarks: "A neighbour of mine, who is said to have a nice ear, remarks that the owls about this village hoot in three different keys—in G flat or F sharp, in B flat, and A flat. He heard two hooting to each other, the one in A flat and the other in B flat. Query: Do these different notes proceed from different species, or only from various individuals?" (*loc. cit.*, pp. 234, 235.)

Other and very interesting remarks by White, on owls, are to be found in his letters. An extract from one in particular I will give you. It is contained in a letter to the Hon. Daines Barrington, whom you may remember hearing of as taking a long journey (in those days) to Mousehole, at the extreme end of Cornwall (close to my native place, and not far from the Land's End), to see and converse with the celebrated old fisherwoman, Dolly Pentreath—said to have been the last person who spoke the ancient Cornish language. White says: "We have had ever since I can remember a pair of white owls that constantly bred under the eaves of this church. As I have paid good attention to the manner of life of these

birds during their season of breeding, which lasts the summer through, the following remarks may not be unacceptable: About an hour before sunset (for then the mice begin to run) they sally forth in quest of prey, and hunt all round the hedges of meadows and small enclosures for them, which seem to be their only food. In this irregular country we can stand on an eminence and see them beat the fields over like a setting-dog, and often drop down in the grass or corn. I have minuted these birds by my watch for an hour together, and have found that they return to their nest, the one or the other of them, about once in five minutes; reflecting at the same time on the adroitness that every animal is possessed of as far as regards the well-being of itself and offspring. But a piece of address, which they show when they return loaded, should not, I think, be passed over in silence. As they take their prey with their claws, so they carry it in their claws to their nest: but, as their feet are necessary in their ascent under the tiles, they constantly perch first on the roof of the chancel, and shift the mouse from their claws to their bill, that their feet may be at liberty to take hold of the plate on the wall as they are rising under the eaves. . . The plumage of the remiges of the wings of every species of owl that I have yet examined is remarkably soft and pliant. Perhaps it may be necessary that the wings of these birds should not make much resistance or rushing, that they may be enabled to steal through the air unheard upon a nimble and watchful quarry. . . When brown owls hoot their throats swell as big as a hen's egg. I have known an owl of this species live a full year without any water. Perhaps the case may be the same with all birds of prey. When owls fly they stretch out their legs behind them as a balance to their heavy heads; for as most nocturnal birds have large eyes and ears they must have large heads to contain them. Large eyes, I presume, are necessary to collect every ray of light, and large concave ears to command the smallest degree of sound or noise" (*l.c.*, pp. 245, 246).

And all these apt quotations naturally bring me back to the main subject of this paper—our little New Zealand owl.

Probably none of you present have ever been in an unfrequented New Zealand forest many years ago—say, half a century, or forty years. Then those woods teemed with bird-life, so widely different to what has obtained of later years. Then our little New Zealand owl was to be often seen snugly ensconced in some sheltered umbrageous nook, and not unfrequently nestling close under the fronds of the tree-fern (*Cyathea dealbata*). There, for me, such would have ever remained unmolested, but not so by the smaller birds—denizens of the forest; for, as soon as his retreat

was discovered by them, the battle, or rather the mobbing, began. The incessant noise the little fellows made brought up their friends from all quarters, and I have been sometimes astonished to see the great number—the cloud—of those small birds so quickly got together; and then, too, their apparent fearlessness or carelessness of my presence, of which they seemed to take no notice, so filled with rage were they and so very intent on insulting their common enemy. But while they would often fly up quite close to him, yet they never laid hold of him or touched him with their beaks; not a feather flew. Still the owl did not like it, and tried hard to get at them without removing from his perch, by thrusting forth his head and fiercely snapping his beak; and while I could see the difference in the dilation of the pupils of his eyes, which sometimes glared on the disturbers of his sleep and peace, yet I doubted if he clearly saw them, although he must have heard them plainly enough. I have never known the owl at such times to make any sound. Occasionally I have seen the so-persecuted bird fly away to some other neighbouring tree or bush; but in so doing he would generally make a woeful mistake, sometimes by coming abruptly against a branch, or between the close-growing canes of supplejacks (*Rhipogonum*), and sometimes by lighting in a less secure place, where the enemy could surround him, and then another fly-away would take place, and I have watched him to fly back to his old quarters; but it always seemed as if there would be no rest, no peace, for him while day-light lasted; and then, no doubt, the tables were turned upon his persecutors with heavy interest.

There being formerly no mice in this country, and I suppose our little New Zealand owl was far too diminutive to attack the now extinct New Zealand rat, and the small birds of the woods being then so exceedingly plentiful, these no doubt formed its chief articles of food, and this the little aerial legions well knew, and so naturally united to persecute him. I have good reasons, however, for knowing that some of our larger insects, especially of the Orthopterous order, as the big grasshoppers in the plains, and the wetas (*Deinacrida* and *Hemideina*) in the forests, formed a portion of the food of our owl; and now since mice have been introduced and become so numerous, and the indigenous small birds on the other hand have become so scarce, our owl does his share in the economy of nature to keep their number down, and therefore should never be wantonly destroyed as if he were an enemy and invader of the "rights of man."

Before I close I would briefly refer to that exquisitely conceived and highly natural legendary fable of the ancient Maoris—viz., the great fixed "battle between the land and

sea birds,"*—which has always served to remind me of Homer's battle between the frogs and mice—in which our little owl, who could not join the great united army of land birds in the long day's sanguinary conflict, owing to his being a nocturnal bird; yet, at the close of that prolonged fight, when the sea birds were utterly routed, distinguished himself by acting as a brave herald-trumpeter, and so added to their fear by joining in the pursuit with his insulting discordant note of ironical derision—*toä koë! toä koë!*—thou (art) brave! thou (art) victor! These words are ludicrously Maorified from the owls' common note of *koū koū! koū koū!* by a kind of onomatopeia—so common among the Maoris, and which a Maori, by a slight twist in the pronunciation, and more particularly when made in the mimicking tone, would cause them to pretty nearly resemble.

Having referred to that ancient Maori fable of the battle of the land and sea birds, in which nearly all our indigenous land birds are brought to the fore to repel the invaders, to fight and to perform prodigies of vălour, even to the including of the piwakawaka, *Rhipidura flabellifera*, Gml.—the pied fantail-flycatcher—I would just call your attention to the grave fact of the total omission of the gigantic moa (*Dinornis*, sps.), and of all allusion to it, as a further proof of what some of you have already more than once heard from me, that *the ancient Maori did not know of its living existence as a bird;* for, if they did, they would have assuredly brought it prominently forward on that occasion as their great hero and redoubted champion, and the dreadful foe of the sea-birds, to whom, as giants in the battle-field, Goliath of Gath, or Og of Bashan, would have been but puny comparisons. That one plain and striking list of negative evidence, *re* the age in which the moa existed, has ever seemed to me to be of far greater value than all the loud and fussy statements of modern Maoris, made to suit the times and the wishes and questions of zealous European inquirers.

ART. XXI.—*On the Birds of Lake Brunner District.*

By W. W. SMITH.

[*Read before the Otago Institute, 10th July, 1888.*]

SINCE the colonisation of New Zealand, less than forty years ago, the flora and fauna of some parts of the country have undergone many changes. This is most marked in the whole

* Translated briefly—together with some other of their ancient fables—by me, in Trans. N.Z. Inst., vol. xi., p. 102.

country east of the central or dividing range, as it has been longer colonised and more adapted to agriculture and the depasturing of sheep and cattle than the bush lands west of the Alps. In the more settled or gold-mining centres of the west coast the same changes—disastrous to the flora and fauna alike—are now proceeding, but nowhere so rapidly as they have done on the east coast. A record of the modification and extinction among the fauna alone since the settlement of the colony would form a volume of great value. But as this is now impossible, it will be well to urge workers in all branches of zoology in New Zealand to collect all available material without delay, and record their researches from time to time. Following this method, I desire to place before this society tonight some observations on the ornithology of the Lake Brunner region of Grey County, West Coast. I am induced to offer a paper on the birds inhabiting the lake district, as the bush remains in its primeval state, and many of the anomalous and more specialised forms, formerly existing, but now extinct, east of the Alps, enjoy in it a fairly genial home. This, however, is destined soon to change, as the new Midland Railway when constructed will extend through part of the valley and near the shores of the lake for half its length. As the country becomes cleared and settled, only a few years will suffice to modify and extinguish much of the rich flora and fauna now existing in these beautiful and stern solitudes.

Very few writers on the zoology of New Zealand have dealt with this subject, yet the ordinary observer cannot fail to have detected the many changes proceeding continuously among various groups of animals. In the orders *Lepidoptera*, *Coleoptera*, *Diptera*, *Orthoptera*, and especially the *Hymenoptera*, a vast number of species have become locally extinct. Some are slowly diminishing, while others remain almost stationary, or continue to increase. In these several orders it will be found that the most specialised forms are the first to succumb. Although many have become locally extinct, or have been driven from their former haunts, some are still found where the features of the country remain unchanged, or the flora less modified. As the land is put under cultivation, or sheep and cattle are put to depasture on the native vegetation, the flora and fauna are soon more or less modified and become partly extinct.

There can be no doubt that the same causes affecting the extinction of our plants and insects can be shown to act in turn on the species of birds now fast dying out. The causes in New Zealand are clearing and cultivation, modification of climate, and the introduction of injurious and predatory forms. As many of our plants and insects are wholly dependent on each other for existence, any cause affecting the one affects the

other. As the supply of insect-food lessens, some species of birds chiefly depending on it decrease according to the supply and rate of reduction. From peculiar habits in the economy of such species, they appear incapable of changing their food, habits, or environment, and ultimately become extinct. The extirpation of other species again is due to the ravages of introduced predaceous animals.

The cold winter of 1883, followed in the spring by severe late frosts, and the continuous cold wet summer of 1883–84, produced a wide-spread failure of the food of many species of birds. In the winter and spring followed the irruption of parakeets, extending over the whole of the east coast of the South Island, and the irruption or "plague" of rats on the west coast, which swarmed into some of the towns and villages. The tui and korimako left their home in the bush and migrated across the open country to procure food. All were in miserable condition and on the verge of starvation. They daily visited the flower-borders, and eagerly probed with their brush-tongues the scarlet and yellow tube-flowers of *Tritomia uvaria*. The same season the wood-pigeon was miserably lean, being compelled to feed on the leaves of the kowhai and other trees, which cannot nourish and fatten like the fleshy nutritious berries of the miro and others. The bush-rats (*Mus rattus*), which depend for food during a part of the year on the ripe berries falling from the trees, were likewise compelled to migrate in search of food. In the same year the habits of the kaka (*Nestor meridionalis*) and the silver-eye (*Zosterops lateralis*) were affected in a similar manner and from the same cause. I collected several specimens of the former in a plantation of English trees near Oamaru, all in a wretchedly weak and lean condition. Their presence was a rare occurrence in the district, which is about thirty-five miles from the nearest native bush. The silver-eye or "blight bird" frequented the gardens in the settled districts in unusual numbers, and attacked the ripe fruits, nothing coming amiss to them. All the species affected were in wretched plumage, and their bodies were infested with a species of *Acarus*.

The New Zealand quail (*Coturnix novæ-zealandiæ*) is often cited as showing how rapidly a species will become extinct. Frequently we hear the old colonists speaking of the great numbers of quail inhabiting the grassy plains in the early days of Canterbury. In a few years, however, without any apparent cause, they vanished, until at the present time not a single living quail exists in the islands. Their disappearance is generally attributed by ornithologists to the burning of sheep-runs or native-grass lands. Probably this is the principal cause which has effected the extirpation of this useful and beautiful gallinaceous bird.

In the early days of the colony, when the species flourished on the plains, vast swarms of caterpillars infested the open grassy country, living in the dense tussock (*Poa*). In a few years after the annual burning of the sheep-runs commenced, the caterpillars disappeared from the plains and attacked the cereal crops, working great destruction among them. Some years after the introduction of the house-sparrow, which increased at an unprecedented rate, the caterpillars were soon reduced in numbers, and are now no more trouble to the agriculturist. They were the larva of the yellow underwing moth, still to be obtained feeding on the introduced Cape broom.

The moth (*Botys polygonalis*) is double-brooded, the first brood appearing in August and September, the second in January and February. The larva is abundant every year, often to such an extent as to cause the complete defoliation of the food-plant. The species would unquestionably increase, and probably again become troublesome to farmers, but for the presence of the house-sparrow, which hunts vigorously in the hedges for the larvæ, and keeps them in check. As the plant is not indigenous, the moth has apparently acquired a special taste in selecting it as the food of the larva, the colours of both assimilate closely, which affords some protection to the species.

On good land, where the tussock-grass is thick and allowed to remain unburned for a number of years, the ground is soon covered with a considerable thickness of dead grass. In this, many species of Coleoptera and the chrysalis of moths can, at all seasons, be found. Such were precisely the natural conditions of the plains in the days of the quail, excepting that they were on a superior scale, and the food-supply at all times more abundant. A fire sweeping over a large area of such country* would effectually annihilate all insect life in its course, and leave the country black and bare. Frequently the fires raged for several days and nights

* Some authors, writing on the moa age, maintain that fires were kindled for the purpose of driving the huge birds on to the sea-shore to enable the hunters to capture them more easily. Supposing such a theory to be tenable, it may be asked, "Why did not the quail become extinct with the moas?" In answer, it may be said that, if ever fire was used as an agent to destroy the moa, its ravages would be confined to small limits, and its progress intercepted by the rivers of the plains. I, however, am not a believer in the fire-theory put forth to account for the extinction of the *Dinornis*. To my mind, the thick grass would be a great protection to the hunters, and would be used by them as an ambush when tracking or surrounding the moas. If the quail existed in New Zealand along with the moas, the burning of portions of the grassy plains occasionally would scarcely affect the economy of the species. It is the annual and wholesale burning of the lands, and the clearing and cultivation that followed, which completed the work of extermination.

together, and spread for many miles across the then open country.

Apart from the utter destruction of the food, the dense tussock afforded the natural warmth and shelter for the birds during inclement weather and chiefly inclement nights; the sudden removal of both would, therefore, act powerfully on the economy and habits of the quail. The species, like other birds in their respective orders now becoming extinct in New Zealand, was a highly specialised form among gallinaceous birds, and depended on special conditions, such as I have pointed out, for its existence. The effects of the fires and of clearing and cultivation on the climate, though perhaps at the time inappreciable to man, would aid likewise in exterminating the species.

No more interesting or profitable district could be visited by the botanist or ornithologist in New Zealand than around the shores of Lake Brunner. The magnificent primeval forest is due to the greater humidity of the lake valley as compared with many other parts of the west coast, and to the great depth of vegetable mould, or rich virgin soil, which covered the whole face of the country before the forest spread over it. I have seen most of the great bush-lands of New Zealand, but nowhere can the vegetation of the bush be seen in such profusion and perfection, rivalling in luxuriance the tropical American forests so fully recorded in the admirable works of Bates on the Amazons, and Belt on Nicaragua.

Among the rich groves of tree-ferns the kakapo (*Stringops*) and the kiwi (*Apteryx*) have their home. In the saplings of taller growth and among the branches of the towering timber-trees many birds revel and enliven the bush through the day with their rich and varied notes. As evening comes on, the calls of nocturnal and semi-nocturnal species are heard. In the dwarf ferns, the weka moves stealthily about, silently peering into the tent, ready to pick up any bright object and carry it off, to be left and lost in the bush. In the branches of decaying trees the kaka is busy searching in the bark and hollows for insects, uttering, as it flies from tree to tree, a hoarse discordant scream. The little owl (*Spiloglaux*) answers from all directions the call of "morepork." The croaking of the kakapo, busily, among the ferns and lower branches, consuming the leaves, and the shrill night-cry of the kiwi, are the only sounds which nightly disturb the serene silence of the forest.

In my paper to-night it will be impossible to treat the subject so fully as I would wish in the limited time; I will, therefore, confine myself to a few remarks on each species in the list here appended. It is possible, however, that other species omitted from the list may exist in the lake region

If so, they must be of rarer occurrence than any I have enumerated, and were never observed there by me. I may add that my object in writing this paper is to illustrate the ornithology of Lake Brunner *as it is* in 1888, and before the physical features of the country are changed and many of the birds become extinct in the district—a result which will inevitably follow the construction of the Midland Railway and the subsequent clearing and settlement.

Appended is the list of birds inhabiting the lake district.

Hieracidea brunnea (Bush-hawk).

It is intensely interesting to watch a pair of these falcons hovering and circling high above the bush, poising motionless for some seconds, and darting forward at intervals to perform their graceful circling flight, meanwhile uttering their "loud petulant scream." Sir Walter Buller, in his great work on the birds of New Zealand, has described the vehement screaming of this hawk when flying high as an excellent indication of changes in the barometer. As there is more bad weather on the west coast than on the east, and the bird is common, I had good opportunities in the vicinity of the lake of noting the screaming of the bush-hawk in relation to the weather, and invariably found it to be succeeded by bad weather. The days on which they perform their high screaming flights is followed by nights of continuous and loud calling of the wekas and kiwis, both of which are equally good indicators of bad weather approaching.

The nest of this little falcon is placed on the top of some old dead tree-stem, broken off some distance from the ground, or in a hanging mass of climbers. It boldly assails any intruder near its eyrie, and screams vociferously while assailing him. As the food-supply is abundant around the lake, and the birds are rarely molested, they will remain common for some years to come.

Circus gouldi (New Zealand Harrier).

I observed the harrier occasionally circling around the mouth of the Ahuna River, an influent near the top of the lake, but it rarely enters the bush in search of prey. Judging from the direct line of flight I have observed them taking, I am of opinion that they pass up the Arnold River from the coast, and cross the open lake as a near route to the open country at the head waters of the Teremakau River, where the species is common. Owing to the dense bush it cannot procure food in the lake valley.

Spiloglaux novæ-zealandiæ (Morepork Owl).

Common around the lake and the whole course of the Arnold River.

Stringops habroptilus (Owl Parrot, or Kakapo).

This remarkable bird is now becoming rare at Lake Brunner. It was exceedingly plentiful at the time of the Kangaroo gold-rush in the district over twenty years ago. Since then it has diminished in numbers, and bids fair to be numbered with other species now rapidly becoming extinct. Being nocturnal in their habits, they emerge from their hiding-places in the evening to feed, and climb among the lower branches, consuming the soft vegetation. When several are feeding together, they continue throughout the night to answer each other's calls, or hoarse mutterings, uttered while masticating their food. On very dark nights it is pleasing to steal as near them as possible and listen to them nibbling at the tender leaves, while they croak and mutter continuously. By the morning their crops are enlarged to their full extent with the nutritious green food consumed during the night. On moonlight nights their sight is clearer, and they take advantage of this to roam farther from their hiding-places to feed. On the outskirts of the bush several may be seen together waddling leisurely along towards some favourite feeding-grounds, returning, when their hunger is appeased, to their usual hiding-place. The latter is generally in or about the decayed roots of old trees or hollow prostrate trunks. It is sometimes easy to find their homes by the presence of little trodden paths leading to them.

Nestor meridionalis (Kaka Parrot).

The kaka parrot is very common in the lake valley. Belonging to the family of honey-sucking parrots, they repair in the spring to the blooming kowhai trees, and regale themselves on the flowers. While thus engaged, they allow a near approach. It is then most interesting to observe them climbing among the pale-green foliage and seizing a bunch of the yellow flowers, carefully and gently pressing the receptacle of the flowers between the tongue and softly-lined overlapping upper beak, and sucking the honey. The structure of the flower is peculiarly adapted to the process, which is performed without any injury to it. The kaka's repast is not, however, obtained without some effort. Naturally somewhat clumsy in their movements, they sometimes experience difficulties in reaching the masses of flowers on the tips of the branches owing to the very brittle nature of the twigs. They, however, fully realise this, and instinctively select the flowers on the stronger branches. When within reach, they hold firmly to the branch and, stretching the neck to its full length, seize and draw the flowers towards them with the beak. One foot is then used to hold the flowers, while the other holds firmly to the branch and steadies the bird when sucking the honey. The weight

of the bird will sometimes cause the branch to bend down to the lower ones, which affords a slight support.

The kaka's habit of breaking twigs with its powerful beak when searching for food is simply to clear its course and to allow more scope and freedom to its movements.

Nestor notabilis (Kea, or Mountain Parrot).

Although the kea is not, as far as I know, an inhabitant of the naked mountain-tops overlooking Lake Brunner, I may here mention that the range of the species continues to extend farther north every year, and may soon extend to the higher ranges in Westland. When Sir Walter Buller published his last paper on the kea five years ago, he gave the ranges on the upper reaches of the Rakaia as its extreme northern limit. During the last three winters it has visited the ranges above the Otira Gorge, thus showing its range to be extending northwards.

Platycercus novæ-zealandiæ (Red-fronted Parrakeet).
P. auriceps (Yellow-fronted Parrakeet).

Both species are abundant in the bush around the lake, the first-named being the most numerous. In fruitful seasons the food-supply of the parrakeets in this district must be prodigious, the berry-bearing trees being both robust and plentiful. The two great irruptions during the last ten years must have considerably lessened their numbers. Severe, late, or early frosts are probably the chief cause of the failure of their food-supply, compelling them to cross over the ranges and devastate the orchards in the eastern districts. During the two irruptions they perished in thousands, as every possible method was tried to trap and destroy them; yet they compensated the settlers to a great extent by consuming the seeds of many noxious weeds, which they attacked when the green fruit in the orchards had been destroyed by them. I often observed them in large flights, consuming the seeds of *Chenopodium urbicum*, an introduced weed, which grows to the height of 4ft. and 5ft., and spreads rapidly. They vigorously attacked the seeds of the various species of *Sonchus*, or sow-thistles; the dock (*Rumex obtusifolius*), which grows in large masses on the bottom of sluggish watercourses; the Yorkshire fog (*Holcus mollis*); and many other injurious plants.

The present year has been an unprecedentedly cold and wet one on the west coast, the result of which will be worth noting, as bearing on the economy of the parrakeets and other species.

Eudynamis taitensis (Long-tailed Cuckoo).
Chrysococcyx lucidus (Shining Cuckoo).

Both species of migratory cuckoos; they visit the bush in

the Grey Valley and Lake District annually in great numbers. They arrive in the first week in October and depart in the middle of March, the large Polynesian species being the first to depart, followed in a week or ten days by the smaller Australian form. After their arrival the long-tailed cuckoo is an object of almost continual persecution by the tuis, which boldly assail and pursue it through the bush, at the same time uttering their wild alarm-call. The superior and dashing flight of the cuckoo, however, soon places it out of danger for a time, and is its only mode of escape, as it is able to offer only a feeble resistance against a number of angry tuis.

Prosthemadera novæ-zealandiæ (Tui, or Parson-bird).

Anthornis melanura (Korimako, or Bell-bird).

In fine weather the bush along the south shores of Lake Brunner re-echoes with the rich notes of the tui and korimako, busy in their season among the blooms of the kowhai (*Sophora tetraptera*) and rata (*Metrosideros robusta*). There is no picture more beautiful in nature than the sight of these two charming songsters, clinging and swinging in grotesque postures in the sunshine on the brilliant crimson blooms of the rata, sipping the nectar, and flying every few minutes to some bough, and uttering their rich song. When suspended, the deep metallic lustre of the tui's plumage contrasts beautifully with the masses of crimson flowers during the season of rata blooms (March and April) so plentiful at the lake. The tui and korimako come to the trees and remain there so long as the blooms support them. They then disperse among the warmer valleys of the bush, and subsist during the wet winter months chiefly on insects, until the return of spring, when the melliferous blooms of the kowhai again supply them with the necessary food. Although both species have disappeared from, or have become rare in, many former haunts east of the Alps, they still exist in great numbers in the Grey Valley and throughout the Westland bush. The tui is much more numerous than the korimako.

Zosterops lateralis (Silver-eye).

This species is exceedingly common in the bush. As the colder weather sets in they congregate in flocks of several hundreds, and leave the higher bush-lands for the lower valleys, visiting the huts and villages of the diggers, voraciously devouring all suitable food which they meet with in their course. Like the kea (*Nestor notabilis*) they have acquired a stong *penchant* for fresh meat, especially raw fat. They eagerly attack the meat in the butchers' shops, fluttering over and hustling each other in their eagerness to obtain food. While thus engaged they utter shrill excited notes, which are pleasing to hear.

Orthonyx ochrocephala (Yellow-head).

Commonest on the south shores of the lake. In some seasons it is more numerous than in others. Some notes are given on this species, associated with the saddleback.

Gerygone flaviventris (Grey Warbler).

The grey warbler is plentiful in all the forests in Westland. As the chief foster-parent of the two species of parasitic cuckoos, the latter will never, under ordinary circumstances, become rare while the rearing of their young is intrusted to the care of this cheerful and industrious little bird. The warbler's merry song is heard throughout the day, as it actively flits through the undergrowth in search of food. It is exceedingly lively in all its actions. While warbling, the white-tipped tail is often spread to form a fan, and its whole motions are full of life and activity. The beautiful pensile nest it constructs is an interesting object in bird-architecture, the site selected being generally on the outer branches of the manuka (*Leptospermum scoparium*) or other dense small-leaved tree or shrub, where it is safe from the attacks of enemies. Although the grey warbler does not decrease in numbers, it cannot be classed with many otherwise favoured species, owing to its having a "double debt to pay"—namely, the rearing of its own brood and the young of the parasitic cuckoos; but nature has fully compensated for this by endowing the species with a life the most active, cheerful, and diligent of all our native birds, and thus enabling it to perform the onerous duties perfectly.

Acanthisitta chloris (Rifleman).

The feeble note of this diminutive bird is oftener heard in the bush than the bird is seen. It is more common near the summits of the lower bush-covered mountains near the lake than in the valleys. It is a very timid species, and has a habit of keeping on the opposite side of the tree-trunks to that on which the observer is moving, which explains the cause of it being very seldom seen.

Xenicus longipes (Bush Wren).

Common some distance up the bushy slopes, where the vegetation is not so dense as near the lake. It delights to climb the moss-covered saplings, searching for minute insects secreted among the moss. When disturbed it utters alarm-notes, which are answered by others near; at the same time it endeavours to conceal itself in the thickest scrub, or, hopping and climbing up the trees, it disappears among the higher branches.

Miro albifrons (South Island Robin).

The wood-robin is an almost constant attendant when roaming in the bush or about the tents. Its habits are in some respects similar to the yellow-breasted tit (*Myiomoira macrocephala*)—jealously chasing each other round the tents, and disputing their rights to crumbs of bread or other food thrown to them. When seated outside the tent they will frequently settle on the boots, darting off to pick up crumbs, returning again and again, and becoming very familiar. They are encouraged and protected by the gold-diggers, who allow them to enter their tents and huts and to hop on the table to share their own meals. The song of the wood-robin in the lonely bush is in all seasons enjoyable. It is the first astir with the earliest streak of dawn, and, with the fantails, is the last to retire in the evening, when the gloomy twilight silently closes over the bush.

Halcyon vagans (Kingfisher).

The kingfisher is abundant about the lake, frequenting the mouths of the streams flowing slowly into it. The food-supply is enormous, as the shallow edges of the streams teem with the small bull-trout.

In autumn, when the grayling ascends the Arnold River, large numbers of kingfishers withdraw from the lake and subsist on the smaller-sized fish of this beautiful and useful species. When the colder months set in many descend the Arnold to the more open and sunny flats on the Grey River, subsisting on insects and small bull-trout "or bullys" until the arrival of the whitebait.

In the Grey during the whitebait season (September and October) the birds are very numerous, and can be seen sunning themselves on dead trees or old naked stumps all along the lower Grey Valley.

Myiomoira macrocephala (Yellow-breasted Tit).

Among the undergrowth of the bush the sprightly yellow-breasted tits flit gracefully about, and sportingly chase each other through the branches, gently fluttering their wings, erecting their crests, and uttering a suppressed twitter as they sit eyeing each other on the boughs or clinging to the stems of the trees, and exhibiting the peculiar jealousy of the wood-robin about the tents. They are plentiful in the district, and more wary than many other species. In the bush near old settled districts on the west coast they are still abundant. Their food, which consists of worms, larvæ, chrysalides, and insects, is plentiful in all seasons in the bush.

Rhipidura flabellifera (Pied Fantail).
R. fuliginosa (Black Fantail).

On the outskirts of the bush the pied and black fantails are daily on the wing, eagerly consuming the sandflies so troublesome in the bush. In dull or wet weather these birds are busy on the shores of the lake, flitting lightly over the water beneath the overhanging branches, and performing graceful evolutions in the air in pursuit of their prey. Both species are abundant around the lake. Their food, the common sandfly (*Limulia australiensis*), is abundant—a fact which is well known to visitors or dwellers in the West Coast bush.

Turnagra crassirostris (South Island Thrush).

The South Island or thick-billed thrush is still fairly numerous at the lake, but has disappeared from the lower gullies of the Arnold, between Stillwater (now named Richardson) and the Arnold gold-diggings. Fifteen or twenty years ago this species existed in great numbers on the Maori Gully goldfield, and fed around the huts and tents of the diggers, frequently entering and hopping on the floors picking crumbs, but gradually their numbers diminished until at the present time not a single thrush exists on the goldfield. Like the British species (*Turdus musicus*), the early morning or evening is the best time to hear its splendid notes and call, or to study its habits, it being then most active. A few hours after sunrise they cease to sing or to answer each other's notes, and generally remain silent in fine weather during the day among the tree-ferns and lower branches of the trees. In dull or wet weather they move about among the higher branches in search of food, and avoid the heavy drip of the thick undergrowth. Like other species, as the wood-robin, the yellow-breasted tit, the crow, and weka, it is easily attracted to the spot where any unusual noise is produced in the bush near its haunts, often coming almost within reach of the individual attracting it, spreading its beautiful rich brown tail, moving sideways along the branch, and turning its body right and left, meanwhile examining the stranger closely. It is, however, a powerful flier, and flies with great precision through the tangled vegetation. I have observed it several times performing such flights; resting almost motionless for some minutes on a high limb of a tree, it would suddenly ruffle its feathers, and, dropping from the limb, fly with great force through the thick undergrowth, reappearing again on a high limb some distance away. One bird I watched uttered a wild jubilant note as it dropped from its perch to repeat its flights from tree to tree. It is probably a habit peculiar to the

pairing season, as I never observed them performing such flights at other times of the year.

Glaucopis cinerea (Yellow-wattled Crow).

This is another remarkable and beautiful species now rapidly approaching extinction. Like other ground-feeders it is exceedingly tame, and falls an easy prey to dogs and cats, large numbers perishing annually from this cause alone. The nest, which is generally placed in some low scrub, is easily reached by cats and rats, and in some localities where both are numerous the parent birds rarely succeed in rearing a brood. While staying at Lake Brunner for fourteen months, and travelling great distances in all directions every day, excepting in wet or windy weather, we never obtained or observed a single young crow. Occasionally an adult bird came around the tents, moving spiritedly, and hopping tamely about the tent-door, picking crumbs or other suitable morsels of food, but only once did we observe a pair together. This occurred two miles up the Ahuna River from the lake, being at the end of October. They were probably paired for the season, and both were in perfect condition, the orange-coloured wattles being most conspicuous. One bird was slightly longer than the other, which, no doubt, was the male. We watched them silently for over an hour to ascertain if they were nesting. They, however, moved on through the bush towards the lake, when we left them, and returned on our course up the river.

Like the preceding species, the South Island crow is a beautiful object in its native haunts, its exceeding tameness allowing a close and perfect study of its habits. When observed clinging to the pale lichen-covered trunk of some old tree, or swinging on the large fronds of tree-ferns, it supplies a picture of bird-life only to be realised by studying birds in their native haunts.

An intelligent workman employed in the Land Survey Department informs me that the species is still plentiful in some of the south-west sounds.

Carpophaga novæ-zealandiæ (Wood-pigeon).

The wood-pigeon is exceedingly common in the Lake District. In fine weather large flights change quarters daily, flying from shore to shore or from one part of the bush to another to visit some favourite or seasonable berry-bearing trees. The presence of numbers of this splendid pigeon in March and April among the graceful foliage of the miro trees (*Podocarpus ferruginea*), moving through the branches and plucking the large fleshy scarlet berries, is another charming picture of bird-life in the New Zealand bush. A plentiful season of miro berries is invariably followed by a season of fat

pigeons. The berries are much relished by the birds, and are exceptionally nutritious and fattening. The nest of this species is placed in the thickest branches of the white and silver pines. As little wind blows in the spring in the forests of the west coast, they experience few difficulties in rearing a good brood annually.

The plumage of the wood-pigeon high among the branches is striking, the bronze-burnished pectus and white abdomen contrast beautifully with the green forest around.

Creadion carunculatus (Saddleback).

This species is sometimes gregarious, and moves through the bush during the colder months of the year in flights of from a dozen to fifty or more together. Several of the old gold-diggers on the River Arnold informed me that they have frequently observed flights of the saddleback following the flights of canaries (*Orthonyx ochrocephala*) as they fed through the bush. Probably no scene in bird-life is more attractive or beautiful than to observe a flock of yellowheads followed by a flock of saddlebacks. On the 2nd June, 1887, I rambled up Stoney Creek, a small stream which flows into the lake a little above the outlet of the Arnold. I had travelled on the banks and bed of the creek about a mile when I turned to the right, up a small narrow gully, in search of ferns or other botanical rarities. On reaching nearly the top of the gully, I heard the shrill, ringing notes of a flock of yellowheads. As I noticed them crossing the gully some distance above me, I moved on gently until I was under the branches on which the birds were passing over the gully. They numbered about two hundred, and were in rich plumage. They fed eagerly for some minutes among the branches of the trees; then, simultaneously uttering their call, they flew forward some yards and began to feed, until they again sounded the signal to advance, repeating it at short intervals, and passed on through the bush in this order.

Before the yellowheads had quite disappeared I heard the rich flute-notes of a flock of saddlebacks advancing. I climbed up the side of the gully and stood on the edge. Two males were the first to appear, followed by the remainder of the flock. They advanced in the line of the yellowheads; not so high among the branches as the latter, but more among the tree-ferns, while some fed among the ferns and mosses covering the ground. When they noticed me some approached closely, twittering, and elevating their tails. They moved about in a sprightly manner on the lower branches, within a few feet of my face, scanning me carefully, and wondering, perhaps, at the intruder on their solitary domain. They were exceedingly tame, and moved with great activity, halting at

intervals, and resting their breasts for a few seconds on the boughs, and again proceeded, searching eagerly for food among the ferns and mosses covering the ground. They were in the perfection of plumage. The saddle-shaped patch of rich brown extending over the back and shoulders, on the lustrous black ground, contrasted well with the deep green fronds of the tree-ferns. The sexes were about equal, and the plumage of some paler than others, which were young birds. They remained hopping on the branches and ferns near me for about seven minutes, and disappeared slowly in the track of the yellowheads.

The purpose served in the saddlebacks' economy in following the flocks of yellowheads is unquestionably to obtain food. The latter, in moving through the bush, will disturb numerous large insects, which they reject, and which are consumed by the saddlebacks following them. The rich insect fauna in some parts of the bush in Westland at certain seasons will account for the appearance of flocks of the native insectivorous birds in these districts. The flights of yellowheads must be entirely regulated by, or restricted to, the supply of food. Where the bush remains in its primeval state they remain numerous; where it is partly cleared or disturbed, this species and many others diminish in numbers and ultimately vanish from the locality. Although the saddlebacks are not dependent on the flights of yellowheads for food, they are able to obtain such by following them, and do not always travel in flocks, as they are occasionally seen singly and in pairs, in some of the gullies of the Arnold and around the lakes, but are now very rare compared to the numbers which inhabited the banks of the Arnold fifteen or twenty years ago.

I was attracted early one morning in March towards some old fallen and decayed timber, where I heard some peculiar tapping sounds. On cautiously reaching the place I found a saddleback busily digging in the decayed timber for the larvæ of the huhu beetle (*Prionoplus reticularis*). The tappings and actions of the bird resembled much those of the green woodpecker (*Picea viridis*) of Britain in its mode of procuring food.

Ocydromus australis (South Island Weka).

Common on the bushy slopes of the mountains on the north side of the lake. It is more common in the valley of the Crooked River than near the shores. They are exceedingly tame and inquisitive, and come about the tents, often remaining around the camp for weeks, picking up crumbs of bread or scraps of meat thrown out. When a number collect near the camp it is almost impossible to sleep, owing to their loud calls through the night. They give much trouble

in camp by entering the tents and pulling or tossing over all movable objects, unless all is left secure.

Ocydromus fuscus (Black Weka).

This darker species or variety is not so plentiful as the preceding one. It inhabits the slopes of the lower bush-clad mountains bounding the lake on the south. It is also a more timid form. But there is no appreciable difference in their call, excepting that this species is slightly the shriller of the two.

Ortygometra tabuensis (Swamp-crake).

The swamp-crake is uncommon about the lake. It frequents the shallow lagoons, concealing itself in patches of *Carex* growing around them.

Porphyrio melanotus (Swamp-hen).

Common in the more open places. They appear to obtain good food, as all I observed were exceptionally fine birds, in perfect plumage:

Himantopus leucocephala (White-headed Stilt).
H. novæ-zealandiæ (Black Stilt).

Both species frequent the shores of the lake and the narrow sandy flats on the Ahuna and Crooked Rivers, the former being the most numerous. It is interesting to stand among the thick vegetation, or behind some tree, and watch them stalking gracefully along the shallow shores in search of food, suddenly taking flight and flying some distance, to recommence the search in fresh places.

Strepsilas interpres (Turnstone).

Occurs among the rough beds of boulders on the Ahuna River, but never at any time numerous.

Hæmatopus longirostris (Pied Oyster-catcher).
H. unicolor (Black Oyster-catcher).

I observed three specimens only of the first-named species at the lake, but I occasionally heard them flying over the district seawards at a great height. The black species inhabits the sands near the mouth of the Ahuna River, but is never very plentiful.

Ardea alba (White Heron).

This magnificent bird—the white crane of the Europeans, the kotuku of the Maoris—still lingers among the secluded lagoons on the bush-flats in the vicinity of Lake Brunner. They are beautiful objects when seen sitting leisurely on the edge of the water. When alarmed they rise, flapping somewhat clumsily, ascending spirally in the air until a considerable height is reached; then, taking some more direct course, the legs are drawn up close to the tail, and they sail away

lightly through the air. I regret that time will not allow of my adding a few more remarks on this splendid species.

Ardea sacra (Blue Heron).

Common in the summer and autumn, when eels and grayling are plentiful in the Arnold and the lake.

Ardea maculata (Little Bittern).

I lately sent a note to the *Ibis* announcing the capture of two specimens of the little bittern on the west coast within the last four years. One was taken at Lake Brunner four years ago; the other was shot last year in a lagoon north of Okarita, and is now in a private collection at Ross. In a rough country like the west coast, still imperfectly explored by ornithologists, it is probable the species may exist in good numbers among the remote lagoons. Naturally an exceedingly shy form, it would readily escape notice, as it is difficult for dogs to work or flush game out of the thick grass and sedges which generally cover the water in a dense mass. I have no doubt that other specimens will be collected as the country becomes cleared.

Botaurus pœciloptilus (Bittern).

Not uncommon among lagoons formed by small arms of the lake, or in the small bays choked with weeds. Also a shy species.

Anas superciliosa (Grey Duck).

During the shooting-season they appear in immense flocks on the lake. They are probably driven thither or take refuge on its waters from the guns of sportsmen in the Grey Valley and other localities. The food-supply is abundant in the weedy creeks and bays of the lake. All the birds we procured were in good condition.

Hymenolæmus malacorhynchus (Blue Duck).

More common on the Arnold River below the lake than elsewhere, where they rest on the stones jutting out of the rapid stream. They ascend the creeks in the bush where they find an ample supply of food. When wounded they are expert divers, diving in the rapid waters and reappearing long distances down stream.

Querquedula gibberifrons (Little Teal).

Common in some parts of the lake, about the sluggish creeks entering it.

Fuligula novæ-zealandiæ (New Zealand Scaup).

Not uncommon in the smaller bays, where it takes refuge among the beds of *Carex* and raupo.

Casarca variegata (Sheldrake or Paradise Duck).

This beautiful species is the largest and handsomest form in the order *Anseres* in New Zealand. It delights to live in the open country near broad river-beds composed of shingle and sand, or on grassy flats near lakes or pools of clear water. It is generally met with in pairs, but can often be seen flying in flocks, changing quarters from one district to another. Occasionally they reach Lake Brunner and disperse along the shores to feed for several days. Reassembling in a flock, they again take flight and leave the lake. Some years they are common in the valleys of the Grey and Teremakau Rivers, frequenting the sandy flats. Owing to the periodical flooding of these two great rivers they are compelled to seek fresh feeding-grounds, and during these short migrations they visit the lake.

C. variegata (Shoveller Duck).

The shoveller or spoonbill duck frequents the larger bays on the west side of the lake. I have detected them among the flocks of grey ducks resting in clear weather on the open lake, but never numerous. They are beautiful objects on the water in spring followed by a brood, and allow a near approach, gliding gently along the shore or into some sluggish creek to nibble among the weeds, or macerating vegetation to procure food for their young. On the west coast their food must differ considerably from that on the east, where they generally inhabit the estuaries of rivers.

Larus dominicanus (Southern Black-backed Gull).
L. scopulinus (Mackerel Gull).

The former is very common during the summer; the latter is an occasional visitant at the lake.

Sterna antarctica (Grey Tern).

Common in the nesting-season in the lake valley.

Podiceps cristatus (Crested Grebe).

The crested grebe has here a safe retreat from the ravages of sportsmen or collectors. No eye can equal the grebe's in its quickness of vision, nor can any bird compare with it for rapid diving. When feeding unobserved along the shore they are gentle and graceful, yet wary, in their movements. When alarmed they draw off into the open lake and are soon lost in the expanse of water.

Podiceps rufipectus (Dabchick).

Not uncommon on the lake; likewise expert divers. They frequent the bays on the north-west shore more than elsewhere, and are generally met with in pairs.

Phalacrocorax novæ-zealandiæ (Black Shag).

P. varius (Pied Shag).

P. brevirostris (White-throated Shag).

All these species inhabit Lake Brunner and the rivers of the lake valley, the pied and white-throated species being most plentiful. There is an ample supply of food at all seasons in the form of eels, grayling, and the two species of bull-trout. There are two shaggeries of *varius* on the Arnold, one on each side of the river below the lake, having about sixty nests in each, placed on trees all more or less overhanging the river. In fine weather they delight to rest in groups of young and old together on gnarled leaning stumps along the shore, some leisurely picking and oiling their feathers, others in easy natural positions, with the head under the wing or drawn close into the body, the plumage of the white-throated shag reflecting brilliantly in the sunshine. Like the blue duck, they rest frequently on the projecting boulders in mid stream, enjoying the spray of the surging waters.

Apteryx australis (South Island Kiwi).

The South Island kiwi exists in considerable numbers in the bush around the lake. It is most numerous on the east and north-east sides, where large patches of *Sphagnum* moss (*S. cymbifolium*) cover the damp bottom of the bush, in the places where the trees and undergrowth are thinnest. They generally live in pairs, and during the night visit the beds of *Sphagnum* moss, probing carefully through it with their long sensitive bill in search of minute larvæ, chrysalides, and worms. They affect the beds of leaf-mould, and probe vigorously through it procuring the large worms existing in the mould. They ramble through the night among the dense beds of ferns, consuming nocturnal insects. Their shrill call is heard loudest on dark and drizzly nights, or before rain, and is answered by other kiwis in every direction,

After examining some of the secluded habitats of the rarer species of birds on the west coast, I have no doubt that an ornithological ramble through the Westland bush, accompanied with one or two good dogs, would yet reveal the existence of *Notornis mantelli*, as the species is of shy and retiring habits. It would in all probability be found in the swampy parts of the bush, or about the sedgy lagoons some distance inland on the southern rivers of Westland. The country is difficult to explore, being composed for the most part of dense and trackless forest. The capture of a single specimen of this *rara avis* would, however, amply repay for all patience and toil expended in exploring the bush. If the *Notornis* still lingers in the South Island, the district I have mentioned is

one of the most favourable where a search may be made for this much prized bird.

The roaroa, or great kiwi (*Apteryx haasti*), is captured occasionally by survey-parties in southern Westland; and this, along with other valuable species, would probably reward the ornithologist for a trip through the west coast bush.

Art. XXII.—*On* Apteryx bulleri.

By R. Bowdler Sharpe, F.L.S., F.Z.S., Hon. Mem. N.Z. Inst.

[*Read before the Wellington Philosophical Society, 13th June, 1888.*]

During a recent examination of some skins of *Apteryges*, in company with Sir Walter Buller, I became firmly convinced that the ordinary brown *Apteryx* of the North Island is certainly specifically distinct from the *Apteryx australis* of the South Island; and I was a little surprised to find, on going over the literature of the subject, that, notwithstanding a similar verdict on the part of such excellent naturalists as Sir James Hector, Sir Julius von Haast, Professor Hutton, Mr. Potts, and others, the North Island bird has not yet received a distinctive name. It has generally been called by naturalists *Apteryx mantelli* of Bartlett, under which name it appeared in the first edition of Buller's "Birds of New Zealand;" and it is the *Apteryx australis* var. *mantelli*, of Finsch's paper in the "Journal für Ornithologie," 1873, p. 263. The characters given by Mr. Bartlett for his *Apteryx mantelli* are founded on the natural variations in *Apteryx australis*, of which *A. mantelli* is a pure synonym; and the North Island *Apteryx* awaits a title. The pair of adult birds in Sir Walter Buller's collection are relatively much smaller than the corresponding sexes of *A. australis*, and the colour is of a blackish brown instead of a tawny tint; while the curious harsh structure of the plumage, especially of the feathers of the rump and nape, is a further character of importance.

It gives me great pleasure to adopt a suggestion of my friend Dr. Finsch that the North Island *Apteryx* should be called *Apteryx bulleri*, after the learned author of the "Birds of New Zealand," a work which in its first edition seemed to me to be as complete as it was possible to make a history of the birds of any single area, until I saw the magnificent new edition on which Sir Walter Buller is now engaged, and on the completion of which I should think any one would find it difficult to write anything more about the birds of New Zealand.

ART. XXIII.—*Notes on the Decrease of Pheasants on the West Coast of the North Island.*

By EDWARD N. LIFFITON.

[*Read before the Wellington Philosophical Society, 17th October, 1888.*]

THAT the pheasant has to a great extent disappeared from the more settled portions of the Wanganui district, where it was formerly plentiful, is an admitted fact; but the causes of that fact are a matter that may be well considered open for discussion. The primary cause is, I think, the great increase of the weka, and the predilection these birds have acquired for eggs. When the pheasants were first introduced into the district they soon increased, and in a few years large bags could be obtained. But at that time the natives lived at many small settlements interspersed, as it were, among the whites; these natives kept a large number of dogs, which were scantily fed, and which, being driven to forage for themselves, lived principally on the weka. The dogs disappeared with the Natives: and to this cause, and also to the large increase of furze hedges, may be attributed the abnormal number of wekas that may be seen any dusky evening in the country; for the furze hedges swarm with them. Now, it is well known that wekas are very fond of eggs, and during the last ten years it is the experience of many farmers' wives that they can get no eggs at all unless the fowls are kept shut up until they have laid; for all nests that were made even quite close to the homestead were and are speedily destroyed, the eggs being eaten by the weka. Wherever the natives are settled it is noticed that there are plenty of pheasants. The habit of keeping a lot of dogs and hardly feeding them at all, thus forcing the dogs to hunt for themselves, and there being generally less furze at native settlements, the wekas cannot so readily escape, and they are thus kept from unduly increasing. When the wekas first acquired a taste for eggs is a matter for conjecture. Is it in their case as with the kea's *penchant* for kidney-fat, and the Nelson parrakeet's proclivity for cherries? I am rather inclined to think it is, but I have no proof. Certainly hens' eggs were not destroyed twenty years ago as they are now, for fowls were allowed to run and breed anywhere. And here it might be asked, how do the wekas discriminate between the eggs of their own tribe and those of other birds? Is it because they cover them? or do they distinguish?

Then there are other reasons: hawks attack the young and sometimes the adult pheasant; rats no doubt assist in eating the eggs; and in those districts where poisoned grain is used it goes without saying the pheasant soon disappears. And in

addition to all these causes there is the fact that the settlers' sons, who were children when the pheasant was first plentiful, are now grown up, and where one gun was carried, now two or more are added.; but I think the weka the principal cause. For, at the Maori clearing on the Wanganui River pheasants are plentiful, as also on the Waitotara River; and they are also to be found, though not so numerous as at Maori settlements, in the newer bush-country opened up during the last four or five years in the Wangaehu Valley. But it may be noticed that as Maori dogs disappear and furze hedges increase the pheasant decreases, and it is very hard to suggest a remedy. The Acclimatization Society for years spent a considerable sum in buying wekas' heads, and thousands were paid for each year, but no perceptible decrease has been noticed, and at last the society have discontinued the practice.

Art. XXIV.—*The Takahe* (Notornis mantelli) *in Western Otago.*

By James Park, F.G.S. (Geological Survey Department).

[*Read before the Wellington Philosophical Society, 17th October, 1888.*]

Up to the present time only three specimens of this remarkable bird have been secured, and, as the opinion has been expressed by some naturalists that it is now quite extinct, I have prepared the following notes, collected during the progress of various explorations in Otago, as tending to show that it not only exists, but is probably as numerous now as when the colony was first settled by Europeans.

I may mention at the outset that the genus *Notornis* was founded by Professor Owen in the year 1848, upon portions of a skull and other parts of the skeleton of a large rail discovered at Waingongoro by the Hon. Walter Mantell, while exploring at that place for moa-bones. These fossils are all that now remain to testify the existence of the *Notornis* in the North Island, where it was known to the natives as the moho.

By a strange and, at the same time, most fitting coincidence, the first two specimens of the *Notornis*, or *takahe* as it was called in the South Island, were secured by Mr. Mantell in 1849. The first of these was captured by a party of sealers at Duck Cove, Resolution Island, in Dusky Sound; and the second by the Maoris on Secretary Island, opposite to Deas Cove, in Thompson Sound. Both of these were forwarded to England, and are now in the British Museum in London.

After a lapse of over thirty years the third specimen was

captured by a party of rabbiters about the beginning of 1880, on the Maruroa Flat, on the east side of Lake Te Anau. This bird was also sent to England, and at the present time probably adorns the shelf of some foreign museum. Since the above date no fresh example of the *Notornis* has been secured, although much time has been spent in the search around Lake Te Anau.

My first acquaintance with this bird dates back to 1881. During the months of January and February of that year I was engaged, with Mr. A. McKay and Mr. John Buchanan, on a geological and botanical exploration of the Wanaka country. On the 20th of January we struck our camp at the forks of the Matukituki, opposite Mount Aspiring, and proceeded up the south branch of that river to Cascade Creek, a distance of eight or ten miles. Here we pitched our tents, at an altitude of 2,000ft. above the sea, in the shelter of the *Fagus* bush which covers all the slopes of the surrounding mountains and the greater portion of the river-flats.

Shortly after dusk our attention was attracted by the call of a strange bird which approached within a few chains of our camp, uttering at short intervals a loud booming note. Now, we were all pretty familiar with the calls of the different birds usually met with in the high lands of Otago, but the call of this bird was quite unlike any of them. We knew also the booming note of the bittern, which, although like this in kind, was left far behind both in volume and intensity. Besides, this was a high, mountainous, bush-covered country, ill adapted for this bird, which usually frequents raupo-swamps and creek-banks. After some deliberation we arrived at the conclusion that this was the *Notornis*, a determination subsequently borne out by facts which came under my own observation.

The next evening, with Mr. McKay's assistance, I lit a large bright fire in the bush, about four chains from the camp, knowing from experience that birds of nocturnal habits were often attracted by the light of a camp-fire. Retiring a short distance from the fire, we awaited the result. As we anticipated, in less than half an hour our friend of the previous evening approached, uttering his booming note as he walked about. We now crawled towards the fire, making as little noise as possible in passing over the dry twigs and leaves lying upon the ground. When we drew near, the bird retreated from the opposite side of the fire, and when we withdrew it again approached. This manœuvre was repeated several times without any success on our part; but at the same time it should be mentioned that the bird, by its movements, exhibited no signs of haste or alarm.

On several occasions we were probably within four yards

of it, and at these times when it uttered its note we could distinctly feel the ground vibrate beneath us. We, however, failed to catch a glimpse of it, as in the intense darkness of the forest this was quite impossible, excepting it chanced to get between us and the fire, which it carefully avoided doing.

The next day I examined the scene of the previous night's adventures, and found that the clear space below the matted branches of the scrub under which the bird had eluded us was about 20in. high, thus affording a means of approximately determining its height.

The *Notornis* remained in the vicinity of the camp during our stay at this place, being evidently more curious than alarmed at our presence. He generally sallied forth at dusk and retired at daybreak, his deep note completely dwarfing the cries of the kiwi and noisy kakapo.

On the 29th January we struck our tents and returned to our old camping-ground near the forks of the Matukituki. Shortly after dusk of this evening we heard the note of a *Notornis*, and, proceeding up the south branch to the upper end of the gorge, I disturbed the bird under a sandbank close to the river. On examining this spot I found that it had scraped a shallow hole in the dry sand, after the same manner, and probably for the same purpose, as the common barn-door fowl.

The river-flats at this place, situated about 1,700ft. above the sea, are covered with a scanty mixed bush, affording but little cover; the ground, however, is thickly strewn with large masses of rock which have fallen from the steep cliffs on the south side of the river, and below which the *Notornis* no doubt found shelter during the day-time.

The next evening I again proceeded to the upper end of the gorge, where the *Notornis* announced his arrival by his loud note. Knowing where to look for it, I approached the bank as cautiously as possible, but, just as I looked over, it scampered away as fast as it could run.

On this occasion I was fortunate enough to catch a passing view of it, although in the uncertain starlight I could only make out its general outline. It must be remembered that it was only in sight a few seconds; but the impression it left upon my mind at the time was that its colour was very dark, and its height about that of a full-grown turkey. An important fact to be noted here is that, although I got within a few feet of it, the bird made no attempt to fly, but ran away very swiftly, and without making any sound or cry of alarm. There can be little doubt that with a sharp dog I could easily have caught it; but, unfortunately, we had no dog attached to our camp at this time.

Seven years now elapsed before the *Notornis* again came

under my observation. At the beginning of this year I visited Dusky Sound for the purpose of examining the mineral deposits discovered there by Mr. William Docherty, the well-known prospector. On the day after my arrival—the 5th January—I accompanied Docherty to his pyrrhotine lode on the lower slopes of Mount Hodge, situated about a mile from the beach. Shortly after commencing the steep ascent we heard the deep booming call of a bird, which I at once recognised as similar to that of the strange bird I had heard in the Matukituki Valley in 1881. After listening for awhile I expressed my belief that this was the *Notornis*. Docherty, however, stoutly denied this, stating that he had often heard the same sound, which was what he called in his own words "a volcanic noise in the bowels of the earth." Without stopping to argue the point, I pressed along, hoping to see the bird, which appeared to be somewhere on our path. The ascent at this point was very steep, our track being along the right bank of a precipitous rocky stream. In a few minutes we got so close to the bird that there could be no doubt whatever as to the organic origin, so to speak, of the sound, which seemed to proceed from the crop of the bird. I now told Docherty to keep quiet for a little, and he would soon see the cause of the booming, at which he became very excited, and shouted loudly that nothing would convince him it was not "a volcanic noise." I need hardly state that we heard nothing more of this bird that day.

On returning to the hut in the evening my field-hand informed me that when he was fishing off the point close by he had heard a takahe in the bush in the direction in which I had been during the day. On asking him what he knew of that bird he said he was one of the party of rabbiters who caught the takahe near Lake Te Anau in 1880; and, as he had often heard the call of that bird and its mate, which, by the way, was never captured, he was quite sure the booming note which he had heard during the day was that of a takahe. In view of the determination I had previously arrived at, I considered this evidence conclusive that this was indeed the *Notornis*. I may mention that this was the first occasion on which I heard the *Notornis* spoken of as the takahe, the only name by which it was known to my field-hand.

That same evening, and every successive evening afterwards during my stay at Dusky Sound, I heard two takahes in the bush at no great distance from the hut. In the course of my various excursions in this sound I heard the takahe at the following places, not including those already mentioned: In the left-hand branch of Docherty's Creek, not far from the open country; at the north end of Cooper's Island; in a gully on the southern slopes of Mount Pender, apparently not far

from the beach; and on the south side of the sound, about opposite the upper end of Cooper's Island.

It will be remembered that the first specimen of *Notornis*, secured by Mr. Mantell, was captured at Duck Cove, Resolution Island, a distance of some seven miles from Cooper's Island; and the second at Secretary Island, in Thompson Sound, about thirty miles further up the coast. After a lapse of over thirty years a third specimen was captured in 1880, near Lake Te Anau; and the following year it was heard in the Upper Matukituki Valley, behind Mount Aspiring, by myself and others of an exploring party; and now, again, in the beginning of the present year, at Dusky Sound, by myself and others. When passing through Wellington some four months ago Docherty informed the Hon. Mr. Mantell that he had recently seen a *Notornis* at Dusky Sound. He said he came upon it in the bush close to the beach, and that it flew some distance on to the water, and then made back to the shore.

I think I have said enough to show that the *Notornis* still exists in the lonely sounds and mountain-recesses of Western Otago, in places far removed from the ordinary haunts of men. That it is gradually becoming extinct is no doubt quite true, but, whatever the cause, it can hardly be said to be on account of the inroads of man. Its extinction is, possibly, partly due to scarcity of food, and partly to a process of natural decay which is no doubt in a measure induced by the effects of the first.

So recluse and retiring in its habits, it is probable that few if any further additions will be made to the three specimens of this bird already secured, unless special efforts be made in this direction; and, though this may entail a considerable expenditure of time and energy, the object is one deserving the support of every true naturalist.

Art. XXV.—*Notes on some New Zealand Birds.*

By T. W. Kirk, F.R.M.S.

[*Read before the Wellington Philosophical Society, 13th February, 1889.*]

1. Rhipidura fuliginosa (Black Fantail, Tiwakawaka).

This bird is generally believed to be confined to the South Island. There are, however, several well-authenticated records of its capture in the North. A specimen was quite recently shot at Levin, a new township on the Wellington and Manawatu Railway Company's land, and presented to the Colonial Museum by Mr. Charles Gillespie.

I have been informed by a settler in the Manawatu district that the season before last a pair of them nested in the bush at the back of his property, and successfully reared their brood. He is positive as to the species. This would seem to show that they are not quite so scarce in the North Island as is usually supposed, even if they are not to be deemed indigenous.

2. Carpophaga novæ-zealandiæ (Wood-pigeon, Kuku, Kereru).

I have yet another instance of abnormal colouring of this magnificent bird to record. The specimen was shot at Kaikoura in June, 1887, and presented to the Colonial Museum by Mr. H. Inglis. The following is a description of it: Head, neck, and breast, normal colour, but of a duller shade. Hind-neck and front portion of scapulars and wing-covers rich brown, profusely interspersed with white (the body of each feather is quite white, but broadly tipped with rich chocolate-brown, which gives the colour to those parts); hind portions of scapulars, and wing-covers, white, the feathers in some places tinged and edged with slaty-grey; shafts of feathers deep-brown, almost black. Wings slaty-grey, much blotched with white, the feathers in most instances edged with coppery-green, shafts normal colour. Rump white, but bluish-grey feathers are profusely mixed. Tail-feathers white, but margined all round with bluish-black, shafts black; below these feathers are white, but so thickly spotted with brown as to appear of that colour; the two outer shafts are nearly white. Abdomen and lower tail-cover white. Sides and lining of wings pale silvery-grey, in places almost white. Beak and feet normal colour.

3. Lobivanellus lobatus (Wattled Plover).

In a previous volume * I recorded the occurrence of the masked plover (*L. personatus*) in New Zealand. The identification was made from a drawing and description supplied to me, but I have since had an opportunity of examining the specimen, which Mr. Drew, in whose possession it is, kindly brought to Wellington for my inspection.

I find that the previous identification was incorrect—that the species is really *L. lobata*, the wattled plover; I therefore hasten to correct the mistake. The two species are very similar, the most striking difference being the amount of black on the neck, which was not sufficiently shown in the sketch.

This species is called the "alarm-bird" by the settlers in some parts of New South Wales, on account of its habit, when disturbed, of rising in the air, flying about excitedly, and

* "Trans. N.Z. Inst.," vol. xx., p. 33.

screaming so loudly that every creature within reach of its cry is on the alert.

4. Chætura caudacuta (Spine-tailed Swift, Needle-tailed Swallow).

Mr. Drew also brought with him a very good specimen of this bird. It was shot at Manaia, Hawera County, in March, 1888, and was given to the present owner by Mr. Budge. This latest visitor is a female, as proved by dissection, the only difference between the sexes being that the male is rather larger than his mate. This species has a wide range—it is said to breed under the snow-line in the Himalayas, it was found by Von Schrenck in Amoorland, it has been captured in England, is common in Australia, and now has visited New Zealand. Large flocks visit the eastern parts of Australia and Tasmania in the summer, but only stay a short time. It is probable that our specimen was merely an exhausted straggler from one of these flocks. It agrees well with the description given by Gould: "Crown of head, back of neck, and ear-coverts, deep shining-green, strongly tinged with brown; a small space immediately before the eye, deep velvety-black; band across the forehead, throat, inner webs of the second-aries nearest the back, a patch on the lower part of the flanks, and the under tail-coverts, white; wings and tail deep shining-green, with purple reflections; centre of the back greyish-brown, becoming darker towards the rump; chest and abdomen dark clove-brown."

Mr. Gould makes the following remarks with regard to the enormous powers of flight possessed by this bird:—

"The keel or breastbone of this species is more than ordinarily deep, and the pectoral muscles more developed than in any bird of its weight with which I am acquainted. Its whole form is especially and beautifully adapted for extended flights; hence it readily passes from one part of the world to another, and, if so disposed, may be engaged in hawking for flies on the continent of Australia at one hour, and in the next be similarly employed in Tasmania.

"So exclusively is this bird a tenant of the air that I never in any instance saw it perch, and but rarely sufficiently near the earth to admit of a successful shot; it is only late in the evening, and during lowery weather that such an object can be accomplished. With the exception of the crane, it is certainly the most lofty as well as the most vigorous flier of the Australian birds. I have frequently observed in the middle of the hottest days, while lying prostrate on the ground, with my eyes directed upwards, the cloudless blue sky peopled at an immense elevation by hundreds of these birds, performing extensive curves and sweeping flights, doubtless

attracted thither by the insects that soar aloft during serene weather."

5. PHALACROCORAX PUNCTATUS (Spotted Shag).

I have already published a description by Mr. McLean of the nesting of this species, as observed near Cape Kidnappers. He has since forwarded me an egg, taken from the nest by himself. It measures $2\frac{4}{20}$in. in length, by $1\frac{8}{20}$in. greatest diameter.

ART. XXVI.—*The Mole-cricket* (Gryllotalpa vulgaris) *in New Zealand.*

By T. W. KIRK, F.R.M.S. (of the Geological Survey Department).

[*Read before the Wellington Philosophical Society, 25th July, 1888.*]

IT is generally believed that New Zealand has no native mole-cricket: this belief is probably correct—at any rate, its existence has yet to be proved; though it is stated, on the authority of Mr. Churton and Major Parry, that one species (*Gryllotalpa africana*) has been found here. This species has, however, a wide range, being found in South Africa, India, and Australia. It is probable that the specimens referred to were introduced from the last-mentioned country; and Professor Hutton, who compiled the "Catalogue of New Zealand Orthoptera" published by the Colonial Museum and Geological Survey Department in 1881, states that he has never seen New Zealand specimens.

I have on previous occasions had to bring under the notice of the society the occurrence of European butterflies and of the scaly lizard in this country, and pointed out that as cultivation extended, and the importation of plants increased, so the introduction and spread of noxious insects would increase, and their depredations become more serious.

The most recent addition of this kind is the English mole-cricket. Some years ago a specimen was brought to me by a son of the late Rev. Mr. Harvey, and I was assured that it had been captured in New Zealand. I, however, took little notice of the matter at that time, and neither saw nor heard anything of further specimens till a short time ago, when I observed some children with the two specimens I now exhibit. The youngsters stated that they had dug them out of a bank on the Tinakori Road, near the Botanical Gardens. Both specimens are immature, but undoubtedly belong to the European species.

In England and on the Continent—especially the latter—the mole-cricket is a terrible trouble, doing incalculable damage in the cornfields, pastures, and gardens. Germany and the south of France suffer most extensively, but the pest is gradually and surely working its way northwards, and is also common in many parts of England, especially in moist districts.

In Germany they have been known to destroy as much as one-fourth of the young corn-crop. They are also very fond of peas, beans, cabbage, and lettuce. Should they find their way into a kitchen-garden they will sometimes destroy whole beds of young plants in a single night. They burrow in the ground and eat the roots, so that the destruction is complete.

One species has of late years caused enormous damage amongst the pastures and sugar-cane plantations in the island of St. Vincent.

They live underground, are large and very powerful, and are said to be capable of propelling a 6lb. weight on a smooth surface. Their fore feet are like those of a mole, and are peculiarly adapted for burrowing. During the day they remain in their burrows, along which they can move backwards or forwards with equal facility, being provided with two filaments at the end of the abdomen, which are used when a backward movement is desired.

These insects are probably familiar to some of you, and I have here specimens and drawings which may be examined, so that it is not necessary I should inflict on you a description of their personal appearance.

At the beginning of summer the female excavates, near her burrow, a cavity shaped somewhat like a lemonade-bottle, with a long neck, which is turned up and communicates with the surface and with her burrow. In this chamber she deposits some three or four hundred eggs. She then carefully seals up the entrance. In about a month or five weeks these eggs, which are about the size of small peas, hatch out, and the young at once commence to feed upon the tender roots of the surrounding plants.

When first hatched they measure only from $\frac{1}{12}$in. to $\frac{1}{8}$in., and are destitute of wings, but when adult they measure nearly 2in., and have wings.

They pass the winter months in the earth, coming forth as spring advances. Their presence may be traced by the little mounds of earth like miniature molehills, and by the yellow withered patches which disfigure pastures and gardens.

I have now seen three specimens captured in New Zealand; it is therefore reasonable to suppose that they have, to some extent at least, established themselves here, and it is probable, in consequence of the rapid progress new pests

always make in this country, that in time, unless great care is taken, we may find the mole-crickets as troublesome as they are in Europe.

Luckily, there are numerous ways of getting rid of them, and nature helps considerably, for the mother herself frequently eats large numbers of her children. Their sense of smell is very acute, and it has been found a good plan to bury a dead crab in the ground infested by them, or pour water with a little oil or turpentine down their burrows, when those not killed will at once vacate.

The mole-cricket, though feeding principally upon vegetation, is really omnivorous, and will take raw beef, grubs, &c., with zest. It has been stated that they are really useful because they do this, but the best authorities give them an unqualified condemnation.

Like their relations, the field-crickets, they are very warlike, and have cannibalistic tendencies, for when an enemy has been vanquished he is sure to be eaten.

Addendum.—Since this paper was read the author has been informed that Mr. Robinson, of Makara, near Wellington, is familiar with the mole cricket, but does not think it has increased in his district during the last two or three years.

ART. XXVII.—*On the Cause of the Disappearance of Young Trout from our Streams.*

By ALEXANDER FERGUSON.

Communicated by T. W. Kirk, F.R.M.S.

[*Read before the Wellington Philosophical Society, 9th January, 1889.*]

DURING the past fifteen years trout-fry have frequently been put into the streams in this district (Palmerston North), but, so far as I am aware, they have never been seen afterwards. Some thought they had been devoured by eels, and others that they had been washed out of the streams by freshes. As it is a subject in which I take considerable interest, and one which has cost many a pound to no purpose, I set myself some twelve months ago to discover, if possible, what was really the matter. It occurred to me that there was little use in examining the streams, or in speculating on the cause of the mischief, and that something more practical would require to

be done. I had a tank erected, 12ft. long by 30in. wide and 24in. deep, divided into three compartments with movable partitions. The front of this tank or aquarium is of glass, so that I can observe all the movements of the fish; and, although I have not a constant flow of water, there is sufficient to answer my purpose. I observed that in all the streams in this district there are large numbers of minnows (*Galaxias attenuatus*), which are pretty to look at, and apparently innocent and timid; but, as they take the worm freely, I thought they might just as readily take the young trout. I placed seven of them in the tank, and gave them worms nearly as long as themselves. These they ate greedily. I then gave them dead whitebait, which they ate as freely. My next experiment was with twenty-five live trout six weeks old; and within twelve hours they had all disappeared except one, which may have been hidden among the plants, and so escaped their observation. By this time I was satisfied that they were at least *one* cause of the mischief, but to make certain I tried once more. I placed two minnows in the tank with fifteen trout nine weeks old; and within half an hour three of the latter had disappeared. I then dissected one of the minnows, and took from it one of the trout, which had been swallowed whole. I may add that the minnows had been well fed before they were placed with the trout; and if they will devour them under these circumstances, we may well understand how readily they will attack them in the streams. There may be other reasons for our want of success in stocking the streams; but, apart from all others, this of itself is sufficient to account for it.

Experience has proved that it will not do to place the young fry in the streams and leave them to take care of themselves, and an important question would be, at what age will they be old enough and strong enough. This I cannot answer definitely. I have had the trout with the minnows when they (the trout) were seven months old, and they seemed to live in harmony. Whether they would do so at an earlier stage I cannot say.

I think if the following plan were adopted we might reasonably look for success: Let the fry be brought from the breeding-ponds, as formerly, when they are, say, four or five weeks old, before they have lost the umbilical sac, for reasons which will be apparent to any one at all acquainted with the subject. Place them in a pond through which there is a constant flow of water, and where other fish cannot get at them. Let them be kept there until they are, say, twelve months old, after which it will be quite safe to turn them into the stream. The pond could be cut out close to the stream from which the water-supply would be taken, and the overflow could go back

to its former channel. I would have a number of large stones in the bottom of the pond to provide hiding-places, as the trout of all ages seem inclined to lie quiet during the day, and come out at dusk to rove about. While kept in the pond they should be fed regularly.

I have pleasure in adding that I have been greatly indebted to Mr. Ayson, of the Wellington Acclimatization Society, at Masterton, from whom I have received much valuable information, and small parcels of trout for experimental purposes.

ART. XXVIII.—*The Distribution and Varieties of the Freshwater Crayfish of New Zealand.*

By CHAS. CHILTON, M.A., B.Sc.

[*Read before the Otago Institute, 11th September, 1888.*]

PLATE X.

FOR some years past I have been engaged, whenever opportunity offered, in forming a collection of freshwater crayfish from the various parts of New Zealand, with a view of determining exactly how many species were represented, and what varieties of these species, if any, existed. By the assistance of several friends I have succeeded in getting a fairly representative collection from both islands, and I now give the somewhat meagre results that I have arrived at from the examination and comparison of specimens from the various localities.

It will be well first to state briefly what has been previously written on the subject.

Miers, in his catalogue of the stalk- and sessile-eyed *Crustacea* of New Zealand (pp. 72, 73), published in 1876, gives three species of freshwater crayfish as inhabiting New Zealand—viz., (1) *Paranephrops planifrons*, White (including under this *P. tenuicornis*, Dana), (2) *P. setosus*, Hutton, and (3) *P. zealandicus*, White.

P. planifrons is well known from many parts of the North Island, and *P. setosus* from the Avon, in North Canterbury, and from other localities in the South Island; but *P. zealandicus* does not seem to have been with certainty recognised since it was originally described by White. It was described in 1847, and, as I have already stated in a previous paper,* Professor Hutton, who described his *P.*

* "Trans. N.Z. Inst.," vol. xx., p. 151.

setosus in 1873, was not then able to consult White's description of *P. zealandicus*, or he would probably, he tells me, not have described his as a new species. I have, in my paper already referred to, discussed to some extent the probability of the identity of these two species, but at that time I was unable to give a decisive opinion on the matter, owing to the want of a sufficiently large collection to examine; and it was chiefly with a view of finally settling the question that I undertook the present investigation.

It is somewhat difficult to compare the descriptions of *P. setosus* and *P. zealandicus*, as they do not run exactly parallel; the differences, however, have been clearly stated by Miers,* who was able to examine the type-specimens of *P. zealandicus* in the British Museum, and to compare them with a specimen of *P. setosus*, Hutton. In speaking of *P. zealandicus* he says, "This species is certainly distinct from *P. setosus*, Hutton. In *P. zealandicus*, of which the type-specimens are in the British Museum collection, the hands are clothed externally with tufts of hair, arranged in longitudinal series, and are armed with spines only on the superior margins; and the sides of the carapace are smooth. In *P. setosus* there are spines arranged seriately upon the external surface as well as the upper margin of the hand, and the branchial and hepatic regions of the carapace are armed with numerous unequal conical spines."

I have specimens, from streams at Dunedin, that agree fairly well with the description of *P. zealandicus* as given in Miers's catalogue; and, though they differ to some extent from *typical* specimens of *P. setosus*, the characters in which they differ vary, as I shall show in detail further on, to a large extent according to size and age, even in specimens taken from the same stream, and such a complete series of transitional forms is found that it will, I think, be necessary to combine the two species under the name *P. zealandicus*, which has priority over *P. setosus* by many years: but, in accordance with the rule suggested by Professor von Martens, and adopted by Professor Hutton, and by Mr. G. M. Thomson and myself,† the name must be written *Paranephrops neo-zelanicus*.

The differences between specimens of *P. planifrons* of different ages and localities are quite as great as those between different forms of *P. neo-zelanicus*; so that, if the latter species were divided, it would be necessary to divide the former also.

The only other reference to two species of *Paranephrops* from New Zealand besides *P. planifrons* that I can find is an

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* "Ann. and Mag. N. H.," ser. 4, vol. xv., p. 412.

† See "Trans. N.Z. Inst.," vol. xvi., p. 187, and vol. xviii., p. 141.

incidental one by Wood-Mason. Speaking of the parasite (*Temnocephala*)* found on these crayfish he says, † "I have since received from my friend Mr. W. Guise Brittan, of Christchurch, New Zealand, an abundant supply of each of *two species* ‡ of crayfish from the rivers Avon and Waimakariri respectively." (The italics are mine.)

In consequence of this notice I was exceedingly anxious to get specimens from the Waimakariri to compare with the Avon species, to see whether they differed or not; but for a long time I was unsuccessful. However, in September, 1885, one of my pupils brought me specimens, not, indeed, from the River Waimakariri itself, but from a creek at Rangiora that empties into one of its branches. These specimens, though differing in some respects from the typical specimens of *P. setosus*, and therein approaching the Dunedin specimens, are not sufficiently distinct to be considered a separate species. I have therefore no doubt that Wood-Mason's specimens all belonged to the one variable species—*P. neo-zelanicus*.

While examining into the identity of *P. setosus* and *P. zealandicus* I have at the same time examined and compared with them specimens of *P. planifrons* from various localities, and find that most of the points of difference hitherto given break down when a large number of specimens is examined, and that it is exceedingly difficult to find constant characters by which to separate them. At one time I was almost tempted to combine the two species (*P. planifrons* and *P. neo-zelanicus*) into one; but, in consideration of the distinctness between extreme forms, I have thought it best to keep them as two species, though with some intermediate specimens it is sometimes hard to decide which species they should be referred to. The various differences will be given in the detailed description further on, but for the sake of greater clearness I will briefly mention some of them here. The squame of the antenna is generally larger in *P. planifrons* than in *P. neo-zelanicus*, usually reaching slightly beyond the extremities of the rostrum and of the peduncles of the antennules and antennæ; but this character fails us in some specimens from Wellington and Pelorus Valley, &c. The sides of the carapace in *P. planifrons* do not, as a rule, bear so many or such well-developed spines as in *P. neo-zelanicus;* but the general arrangement is much the same, and some specimens of *P. planifrons* (as, for

* See below, Art. xxix.

† "Ann. and Mag. N. H.," ser. 4, vol. xv., p. 336.

‡ He gives the name of one species only, however—viz, *Astacoides zealandicus*=*Paranephrops setosus*, Hutton.

instance, those from Nelson) are very spiny, while many of *P. neo-zelanicus* have the carapace almost smooth. In *P. planifrons*, again, the infero-posterior corner of the pleura of the abdominal segments is usually distinctly angular, while it is more or less rounded in *P. neo-zelanicus;* but this character, again, varies considerably in both species. The character that I have found most useful in distinguishing the two species is in the form, &c., of the great claws. In *P. planifrons* these are long, and have the basal portion of the propodos (without the fixed finger, that is) usually fully twice as long as the carpus, and generally more than twice as long as broad; and, though it sometimes bears a few scattered hairs, these are never abundant and are not arranged in tufts. In *P. neo-zelanicus* the propodos is usually somewhat compressed, it is generally less than twice as long as the carpus, and not more than twice as long as broad, and it is always abundantly covered with hairs arranged in tufts. The relative sizes of the different joints vary to a considerable extent; but I have found the abundant hairs in all my specimens of *P. neo-zelanicus*, and this forms the only character that I have been able to rely upon in all cases to distinguish this species from *P. planifrons*.

It has generally been stated hitherto that *P. planifrons* is confined to the North Island and is not found in the South, but is represented there by *P. neo-zelanicus*. In August, 1883, however, I received from the late Mr. J. C. Gully two very fine specimens of *P. planifrons* from a stream—the Maitai—at Nelson. It would hence appear that Cook Strait has not proved so great, or, rather, so old a barrier to these crayfish as the mountains in Nelson forming the northern continuation of the Southern Alps. As this point seemed to be of some importance in connection with the geographical distribution of the fauna of New Zealand, and as I was ignorant of the configuration of that part of the South Island, I applied to Professor Hutton for information. With his characteristic kindness and promptness he at once told me that there was no great division (by mountains, that is) between Nelson and Greymouth, but that the first great division would be along the Kaikoura Mountains and across westerly to Mount Franklin, and then down the Spencer Mountains and the Southern Alps; though the part between the Kaikoura Mountains and Mount Franklin is much broken by rivers, some running north and some south. He also told me that several North Island plants extend to Nelson and down the west coast to Westport and Greymouth. Another fact pointing in the same direction is found in the distribution of *Armadillo speciosus*, a terrestrial isopod. This is known from the North Island (Bay of Islands, *Dana*, and Wellington, *Hutton*), and I have specimens

from Nelson; but I have never heard of it occurring in the southern part of the South Island.

It was therefore to be anticipated that specimens of *Paranephrops* found north of the dividing-line mentioned by Professor Hutton would, like those from Nelson, belong to *P. planifrons* rather than to *P. neo-zelanicus*. To test this I applied to Mr. J. Rutland and Mr. R. Helms, and these gentlemen very kindly supplied me with specimens from Pelorus River and Greymouth respectively. These specimens, though to some extent intermediate, like those from Nelson, are without the characteristic tuft of hairs found in *P. neo-zelanicus*, and therefore belong, as I had anticipated, to *P. planifrons*, the North Island species.

The crayfish seem to be very widely distributed over all the different parts of New Zealand. Of *P. planifrons* I have specimens from Karaka, Manukau Harbour; Puriri Creek, Thames; Lake Roto-iti; Napier; Wellington; Nelson; Pelorus River; and Greymouth: and of *P. neo-zelanicus* from various streams in North Canterbury, from Oamaru, and from Dunedin. I have also heard of it from Southland and various portions of the interior of Otago, and Mr. G. M. Thomson has taken it in Stewart Island and in the western tributaries of the Waiau, in the south-west part of Otago.

A freshwater crayfish belonging to the same genus as those of New Zealand—*Paranephrops*—is said to be found in Fiji, and is mentioned by Professor Huxley in "The Crayfish," p. 313, and also in his paper in the "Proceedings of the Zoological Society," 1878, p. 770. In "The Crayfish," p. 313, he states that "considering their wide separation by sea, the amount of resemblance between the New Zealand and the Fiji specimens is very remarkable." As this fact is of some importance in connection with the question of the origin of the New Zealand fauna, I have in several ways endeavoured to get specimens from Fiji for comparison with those of New Zealand, but as yet I have been unable to hear of any one in Fiji who would collect them for me. It appears that the statement that *Paranephrops* is found in Fiji rests on two specimens in the British Museum, and I notice that Professor W. Faxon suggests that the locality-labels are perhaps erroneous.*

Before proceeding to give detailed descriptions of *P. planifrons* and *P. neo-zelanicus*, I desire to take this opportunity of thanking those friends who have kindly provided me with material—viz., Mr. T. F. Cheeseman, Auckland; Mr. A. Hamilton, Napier; Mr. T. W. Kirk, Wellington; the late Mr. J. C. Gully, Nelson; Mr. J. P. Grossman, Christ-

* "Revision of the Astacidæ," part i., p. 2 (footnote).

church; Professor Parker and Mr. T. Butement, Dunedin; Mr. J. Rutland, Pelorus Valley; and Mr. R. Helms, Greymouth.

I shall now give a somewhat detailed description of the external characters of *P. planifrons*, taking one of the Napier specimens as a fairly typical one, and then briefly pointing out the variations found in other specimens. I shall do the same with *P. neo-zelanicus*, taking a specimen from the River Avon as the type. Further detailed information will also be given in a tabular form in an appendix, and brief diagnoses of the two species are also added. I may explain that I have examined only those external characters that are usually taken for the purpose of distinguishing different species of crayfish, and I have only concerned myself with the New Zealand species of *Paranephrops*, and have not compared the genus with other genera of the *Potamobiidæ*—this comparison will, I hope, be made by Professor Walter Faxon (to whom specimens have been sent) in the second part of his "Revision of the Astacidæ.

Description of Napier Specimen of *P. planifrons*.

The specimen is a male, 5·25in. in length from the tip of the rostrum to the end of the telson; the greatest breadth is 1·2in.; the length of the antennæ is about 4in., and of the great claws 4·5in. The rostrum is elongate triangular, with raised margins bearing four spines on each side; it is keeled below, and on the keel bears two median spines, which can be seen from below just between the peduncles of the antennules. It will be convenient to represent the spines on the rostrum by the formula $\frac{4-4}{2}$, the figures above the line giving the number of spines on the right and left sides respectively, the figure below the line indicating the median spines on the keel below. The carapace is nearly circular in transverse section, the surface somewhat scabrous, most parts covered with very fine hairs placed singly; the spines and tubercles are mentioned below. The short median ridge behind the rostrum begins slightly in front of the posterior termination of the two lateral ridges of the rostrum; it is clearly marked in front, but becomes less distinct posteriorly, and disappears about half-way between its anterior extremity and the cervical groove. At the base of the rostrum on each side are two spines behind the eyes; there is a row of hairs between them and a tuft in front of the anterior spine; from the posterior spine a slight ridge extends backwards about as far as the posterior end of the median ridge. The spines on the carapace may for the sake of convenience of reference be divided into the following arbitrary groups (see Plate X., fig. 2):—

(1.) On the portion of the carapace in front of the cervical groove:

Group A, containing the two spines at base of the rostrum on each side.

Group B, two spines behind the eyes and below A.

Group C, three or four spines on anterior margin of the carapace, near the bases of the antennæ.

Group D, two or more spines on the part of the carapace posterior to C, and in front of the cervical groove.

Group E, one or two spines below D, and usually on a slight projection of the carapace.

(2.) On the portion of the carapace behind the cervical groove:

Group F, two spines immediately behind the cervical groove, and between it and the branchio-cardiac grooves, which here extend forwards and outwards towards the cervical groove.

Group G, four spines close behind the vertical portion of cervical groove below and in front of F.

Group H, six or seven spines along the cervical groove where it curves horizontally forwards (below group E).

Group J, includes the spines and tubercles on the branchiostegites, excluding those bordering the cervical groove and already enumerated. About six of the more anterior are distinctly spinous, the others gradually degenerate posteriorly into mere tubercles.

The peduncles of the antennæ and antennules both reach about to the end of the rostrum; that of the antenna bears several spines on the under surface of the different joints. The squame of the antenna is large, and reaches rather beyond the end of the rostrum; it is triangular, narrowing anteriorly, and at the end narrowing abruptly to a sharp point; the inner edge is fringed with long setæ, and there is a deep longitudinal groove above. The anterior part of the epistoma, between the bases of the antennules, is broad, triangular, and flat, ending anteriorly in a sharp spine. The great claws are large and long, being about six-sevenths the length of the body. The propodos is not compressed, and its length (excluding the fixed finger) is about twice as great as that of the carpus, and about three times its own width; it widens slightly towards the distal

end. The whole limb is densely spined: the basos has one spine on the inner margin; the ischios has a few on the inner margin, and one or two indistinctly marked on the outer margin; the meros has two irregular rows on the inner margin, and one row on the outer margin, and one spine on each side of the hinge; the carpus is spined all round, with a slight groove above, between two longitudinal rows; the propodos is densely spined in longitudinal rows, the largest spines being on the upper surface and the inner margin, and in one row of about six on the lower surface; there are two very regular rows on the outer margin, extending right to the end of the fixed finger. Both fingers are very spinous, inner margins with rounded teeth and a few hairs, the fingers ending in incurving spines. The pleura of the abdominal segments have the infero-posterior corner distinctly angled, the anterior edge being longer and more convex than the posterior, which, though slightly sinuous, scarcely curves forward; the anterior edge alone fringed with setæ.

The specimen I have described is the largest of *P. planifrons* that I have seen. I have two others from Nelson, 4·8in. long, and others from Lake Roto-iti, 4·15in. and 4in. long. On the other hand we may have mature specimens very much smaller: thus I have a female bearing eggs, from the Thames, only 2·4in. long, and another, from Wellington, 2·5in. From the measurements given in the table below it will be seen that the proportion of the greatest breadth of the carapace to the length varies to some extent, but is almost always less than one-fourth the length. When seen in dorsal view the sides of the branchiostegites are nearly parallel, so that the carapace is about the same width throughout the whole length of the branchiostegites. The sides, however, sometimes bulge slightly in the centre, but not to so great an extent as the Avon and Heathcote specimens of *P. neo-zelanicus*. (See Plate X., fig. 1, and compare it with fig. 1*a*.) The number of teeth on the rostrum varies very greatly, and very often differs on the two sides; the median teeth below are sometimes entirely absent, as in the Pelorus River specimens, where they are present in one specimen only. The spines, too, vary in distinctness, being very sharp and distinct in the Nelson and Greymouth specimens, but blunt and more or less rounded at the end in those from Lake Roto-iti. The rostrum is frequently depressed, as in the Napier specimen, but, again, is often quite horizontal, or only very slightly depressed. The median ridge on the carapace, behind the rostrum, varies much in length and distinctness, but usually does not extend so far back as in *P. neo-zelanicus*. With regard to the spines on the carapace, it must be remembered that the groups into which I have divided them, though useful

for easy reference, are purely arbitrary, and may not always be clearly distinguished. The spines often vary both in number and position on the two sides of the same specimen. In some specimens the spines are almost entirely absent, so that the whole of the carapace is nearly smooth; but usually some of the groups are represented, if not by spines, by small tubercles corresponding in position to the spines in other specimens. I have tabulated the number of spines of each group found in various specimens, and, though I need not give the tables, I can summarise some of the results here. Group A contains only two spines, and is invariably present; group B is frequently altogether absent, but may contain several spines, as in the Nelson specimens, extending into group D and group K, mentioned below; group C is usually represented, but often only by very small spines; group D is often absent in small specimens, but may contain as many as six spines, extending right back to the cervical groove; group E is seldom entirely absent, and never contains more than two spines; group F is often absent, and the spines in it are never large; group G is one of the most constant, and contains some of the largest spines, it is seldom entirely absent; group H, again, is also usually represented, though the number of spines varies very much, and they are sometimes very small and close together, so as to form only a row of more or less spinous tubercles; group J, including the spines and tubercles on the branchiostegites, is very variable—sometimes the spines are entirely absent, so that this part of the carapace is quite smooth, at other times the spines are represented by slight roughness only, but, again, as in the Nelson specimen, the whole of the branchiostegite may be thickly covered with well-developed spines. In the specimen from Nelson, two other groups, present in many specimens of *P. neo-zelanicus*, but not represented in other specimens of *P. planifrons*, are noticeable: they are, group K, containing 4–5 spines in front of the cervical groove and behind group B; and group L, containing two or three small spines on the cardiac portion of the carapace, usually by the sides of the branchio-cardiac grooves. (See Plate X. fig. 2*a*.) In this Nelson specimen the number of spines in each group is much greater than usual, and they run into one another so much that, as in some specimens of *P. neo-zelanicus*, it is difficult to distinguish them into the different groups. In the Lake Roto-iti specimens the spines are usually more or less blunt, and often degenerate into tubercles.

The squame of the antenna sometimes reaches only as far as the extremity of the rostrum, instead of beyond it as in the Napier specimen. The inner edge is generally straight in the centre, or even slightly concave; but sometimes more convex, as it usually is in *P. neo-zelanicus*. Towards the end it often

narrows somewhat abruptly, so that a portion of the margin here is very convex; I have never, however, seen it produced into a distinct point, as shown in Dana's figure of *P. tenuicornis*, and think this must be due to an exaggeration on the part of the artist. (Compare figs. 3 and 4 of Plate X.) The spines on the under surface of the joints of the peduncle of the antenna are often entirely absent in small specimens, even though sexually mature. The length of the antenna varies considerably (see table below): it may sometimes, as in Nelson specimens, be greater than that of the body itself. The great claws, again, vary very greatly, both in proportion to the body and in the shape and relative size of the different joints. Large, well-developed forms have the propodos long and thick (*i.e.*, not compressed), and are easily distinguished from those of *P. neo-zelanicus;* but in others the propodos is somewhat compressed, and is not so long in proportion to its breadth, thus approximating in appearance to those of *P. neo-zelanicus*. In the large specimens the propodos is often fully three times as long as broad, but in some specimens from the Thames, Greymouth, &c., it is not more than twice as long as broad, and in these it does not widen distally as it usually does in the others. In the same way the spines on the great claws vary to quite as great an extent as those on the carapace, but it would be tedious to enter into detail. In the Lake Roto-iti specimens those on the propodos are nearly all more or less tubercular, instead of being distinctly spinous, as is usually the case. The propodos, especially in the smaller specimens, often bears a few scattered hairs, but these are never arranged in tufts as in *P. neo-zelanicus*.

The distinctness of the infero-posterior angle of the abdominal pleura also varies very considerably, and it is sometimes quite rounded, as in *P. neo-zelanicus*.

Description of Avon specimen of *P. neo-zelanicus*.

As this specimen agrees in many respects with the one of *P. planifrons* already described, I shall only give those points in which it differs. The length of the body is 4·85in., greatest breadth 1·2in., length of antennæ 3·5in., of great claws 3·5in. The branchiostegites bulge considerably in the centre, so that the breadth here is much greater than in front of the cervical groove. The rostrum has $\frac{4-4}{1}$ as the formula for its spines, and is only slightly depressed. The median ridge behind the rostrum begins on a level with the anterior of the two spines at the side, and extends about three-fourths of the way back to the cervical groove. The spines on the carapace are very numerous, several of the groups running into one another. They may be briefly described as follows, using the same

groups as in *P. planifrons:* Group A, two, as usual; B, three or four, irregularly placed; C, five, but not arranged so regularly on the margin of the carapace as in *P. planifrons;* D, six, extending right back to the cervical groove, and running anteriorly into C; E, one, situated on slight prominence; F, two; G, four or five, very strong, extending into H; H, a row of about seven, extending along the under margin of the groove; J, the whole branchiostegite covered with well-developed spines, all sharp and distinct except those on the lower portions, which are rubbed by the legs and are rounded at the end—the spines extend much further up than is usual in *P. planifrons*, reaching almost to the branchio-cardiac grooves; K, a group of about eight well-marked spines; L, two or three small spines along the branchio-cardiac groove on each side. The squame of the antenna scarcely reaches beyond the extremity of the rostrum, and has its inner margin more convex than is usually the case in *P. planifrons*. The anterior portion of the epistoma is quite narrow, and ends anteriorly in a sharp spine. The great claws are much shorter and stouter than in extreme forms of *P. planifrons*, and have the propodos and the fingers thickly covered with dense tufts of hairs, chiefly arranged in longitudinal rows. The ischios and meros are somewhat *laterally* compressed, so that it will be convenient in describing the spines on them to speak of the upper and under *edges* and the outer and inner *sides;* the carpus and propodos are more or less *vertically* compressed, so that we can distinguish here the outer and inner *edges* and the upper and under *sides*. The spines on the great claws are then arranged as follows:—

Ischios—*Upper edge*, two blunt spines.
Under edge, two sharp spines.

Meros—*Upper edge*, one row dividing into two at the end, where there are also a few spines irregularly placed.
Under edge, two diverging rows, containing four to six spines each; one large spine at distal end between the two rows, and others placed irregularly.
The *outer* and *inner sides* of these joints without spines.

Carpus—Spined all round, the largest on the outer and inner edges; on the upper side the central portion is flat and free from spines.

Propodos—*Inner edge*, a row of four strong spines.
Outer edge, two rows, containing about twelve spines each, extending right along to the end of the fixed finger.

Upper side, various spines, chiefly arranged in two longitudinal rows.

Under side, spines chiefly arranged in two longitudinal rows; strong spines in the centre.

The fingers end in strong incurved spines, inner margins with three or four rounded prominences. The propodos (without the fixed finger) is one and a half times as long as the carpus, and about twice as long as broad. The pleura of the abdominal segments is quite rounded below, and has setæ both on anterior and posterior margins. (See Plate X., fig. 2*a*.)

All the parts I have thus described are subject to much variation, as in *P. planifrons*, and I need not go over each in detail, but only mention those in which this species sometimes differs from *P. planifrons*. The bulging of the branchiostegites is only found in the specimens from the Avon and Heathcote; the others have the sides straight as in *P. planifrons*. The epistoma is often narrow, but is sometimes broad, flat, and triangular, as in *P. planifrons*. The spines on the sides of the carapace vary very greatly: in large specimens, especially those from the Avon and Heathcote, they are very numerous and prominent; but in others, from Rangiora and Dunedin, only a few are represented, and the greater part is quite smooth. Some of these specimens would correspond fairly well with the description of *P. zealandicus*, White, as given in Miers's catalogue. The relative lengths of the joints of the great claws vary a good deal, as in *P. planifrons;* but these limbs are usually shorter and broader than in that species. The pleura of the abdominal segments often have the infero-posterior angle more pointed than in the Avon specimens, thus approaching *P. planifrons*. The large specimen in the Otago Museum, labelled *P. setosus* in Professor Hutton's handwriting, is the largest I have seen, being 6·8in. long; the sides of the branchiostegites are quite straight; the spines on the carapace, though numerous and well marked, are all rounded at the end, so as to be almost tuberculiform; the propodos of the great claws is very little compressed, and somewhat resembles that of *P. planifrons*, though stouter; and the upper margin bears very few spines, the tufts of hairs arising out of small tubercles instead.

In both species the females, especially when bearing eggs, have the abdomen wider than it is in the male, but beyond this I have noticed no other differences between the sexes.

I append brief diagnoses of the two species, with the synonymy so far as it is known to me.

PARANEPHROPS PLANIFRONS.

Paranephrops planifrons.

White, "Zool. Miscel.," p. 79 (1842).
Dieffenb., "Voy. New Zealand," ii., p. 267 (1843).
Miers, "Zool. 'Erebus' and 'Terror,'" Crust., p. 4, pl. iii., fig. 1 (1874); "Cat. N.Z. Crust.," p. 72 (1876).
Huxley, "Proc. Zool. Soc.," 1878, p. 770.

Paranephrops tenuicornis.

Dana, "U.S. Exped.," xiii., Crust., part i., p. 527, pl. xxxiii., fig. 4 (1852).

Basal scale of antennæ large, narrowing abruptly anteriorly, with deep groove above, reaching as far as or beyond the extremities of the rostrum and of the peduncles of the antennæ and antennules. Carapace nearly cylindrical, of same width throughout whole length of the branchiostegites, being a little less than one-fourth the total length of body; smooth, or with small tubercles on sides of branchiostegites, and spines along the cervical groove and elsewhere; two spines on each side of the base of the rostrum. Rostrum elongate, triangular, sometimes depressed, margins raised and usually with four teeth on each side, under surface keeled and usually with two teeth. Median ridge behind the rostrum clearly marked in front, arising slightly in front of the two lateral ridges of the rostrum, and reaching about half-way from its anterior extremity to the cervical groove, disappearing gradually. Anterior portion of the epistoma triangular, flat, narrowing anteriorly, and ending in a sharp spine. Great claws long, slender, propodos (without fixed finger) about twice as long as the carpus and about two and a half times as long as broad, whole limb densely spined; spines on propodos arranged more or less regularly in longitudinal rows, and with occasionally a few scattered hairs. Pleura of abdominal segments rather pointed at the infero-posterior angle, anterior edge longer and more convex than the posterior and fringed with setæ, posterior edge sinuous and scarcely curving forwards.

Length of largest specimen, 5·25in.

Habitat. North Island generally, and the north-western portion of the South Island as far south as Greymouth.

PARANEPHROPS NEO-ZELANICUS.

Astacus zealandicus.

White, "Proc. Zool. Soc.," p. 123 (1847); "Ann. and Mag. Nat. Hist." (ser. 2), i., p. 225 (1848).

Paranephrops zealandicus.

Miers, "Zool. 'Erebus' and 'Terror,'" Crust., p. 4, pl. ii., fig. 2 (1874); "Cat. N.Z. Crust.," p. 73 (1876); "Ann. and Mag. Nat. Hist." (ser. 4), xv., p. 412 (1876); "Trans. N.Z. Inst.," ix., p. 475 (1877).

Chilton, "Trans. N.Z. Inst.," xv., p. 151 (1883).

Astacoides zealandicus.

Wood-Mason, "Ann. and Mag. Nat. Hist." (ser. 4), xv., p. 336 (1876).

Paranephrops setosus.

Hutton, "Ann. and Mag. Nat. Hist." (ser. 4), xii., p. 402 (1873).

Miers, "Cat. N.Z. Crust.," p. 72 (1876); "Ann. and Mag. Nat. Hist." (ser. 4), xv., p. 412 (1876); "Trans. N.Z. Inst.," ix., p. 475 (1877).

Chilton, "Trans. N.Z. Inst.," xv., p. 150 (1883).

Basal scale of antennæ like that of *P. planifrons*, but not narrowing so abruptly, and extending only to the end of the rostrum. Carapace nearly cylindrical, greatest breadth generally a little less than one-fourth the length, of the same width throughout whole length of the branchiostegite, or bulging in centre; carapace nearly smooth, or with spines along the cervical groove and on the branchiostegite and elsewhere, spines usually more numerous than in *P. planifrons;* two spines on each side of the base of the rostrum. Rostrum elongate, triangular, sometimes depressed, margins raised and usually with four teeth on each side, under surface keeled and usually with two teeth. Median ridge behind rostrum arising on level with the first of the two spines at the base of the rostrum and extending backwards three-fourths of the distance to the cervical groove. Anterior portion of epistoma flat and triangular, or narrow, ending anteriorly in a sharp spine. Great claws stout, propodos usually compressed, one and a half times as long as the carpus and nearly twice as long as broad, both sides covered with small tufts of hair and with stout spines arranged chiefly in longitudinal rows. Pleura of abdominal segments usually rounded below, anterior edge longer than the posterior, which curves forward, both edges fringed with setæ.

Length of largest specimen, 6·3in.

Habitat. South Island generally, excepting north-western portion; Stewart Island.

TABLE OF MEASUREMENTS, ETC., OF DIFFERENT SPECIMENS.

Description of Specimen.	Length in Inches.	Greatest Breadth in Inches.	Length of Antennæ in Inches.	Length of Great Claws in Inches.	Spines on Rostrum.
Paranephrops planifrons.					
Napier specimen No. 1, ♂	5·25	1·2	4	4·5	$\frac{4-4}{2}$
" " No. 2, ♀	4·7	1·1	Broken	3·2	$\frac{5-4}{3}$
Roto-iti " No. 1, ♂	4·15	1	2·75	3	$\frac{4-4}{1}$
" " No. 2, ♂	4	1	3·5	3	$\frac{3-3}{2}$
Manukau " No. 1, ♀	3·25	0·7	3	2·25	$\frac{3-3}{2}$
" " No. 2, ♂	2·85	0·55	2·4	2	$\frac{4-4}{2}$
Nelson " No. 1, ♂	4·8	1·1	5·3	4·1	$\frac{4-5}{1}$
" " No. 2, ♂	4·8	1·1	4·6	4·1	Broken
Thames " No. 1, ♂	3	0·6	2·75	2·4	$\frac{3-2}{1}$
" " No. 2, ♀	2·4	0·5	1·9	1·6	$\frac{3-3}{1}$
Wellington specimen No. 1, ♀	2·5	0·5	1·7	Wanting	$\frac{6-5}{2}$
Greymouth specimen No. 1, ♀	3·5	0·8	3·2	2·4	$\frac{4-4}{2}$
Pelorus Valley specimen No. 1, ♀	3	0.6	2·5	2	$\frac{5-4}{0}$
Paranephrops neo-zelanicus.					
River Avon specimen No. 1, ♂	4·85	1·2	3·5	3·5	$\frac{4-4}{1}$
River Avon specimen No. 2, ♂	5·8	1·5	4	4·25	$\frac{5-5}{3}$
River Avon specimen No. 3, young ♀ ..	2·2	0·45	1·7	1·35	$\frac{6-3}{1}$
River Heathcote specimen No. 1, ♀	3·6	0·85	2·75	2·25	$\frac{4-5}{2}$
Rangiora specimen No. 1, ♂	3·9	0·9	3	2·8	$\frac{4-4}{1}$
Oamaru specimen No. 1, young ♂	2·5	0·5	1·6	1·7	$\frac{5-6}{1}$
Dunedin specimen No. 1, ♀	2·8	0·5	1·9	1·7	$\frac{5-4}{0}$
Dunedin specimen No. 2	6·3	1·5	4·5	5	$\frac{5-6}{2}$

In the above tables I have given only a small selection of the specimens that I have examined and measured.

DESCRIPTION OF PLATE X.

Fig. 1. *Paranephrops planifrons* (Napier specimen); carapace from above.
Fig. 2. *The same*; side view, to show arrangement of spines, &c., on carapace.
Fig. 3. *The same*; squame of antenna.
Fig. 4. Squame of antenna of *Paranephrops tenuicornis*, Dana (after Dana).*
Fig. 1*a*. *Paranephrops neo-zelanicus* (Avon specimen); carapace from above.
Fig. 2*a*. *The same*; side view, to show arrangement of the spines, &c., on carapace.

NOTE.—All the drawings are semi-diagrammatic.

ART. XXIX.—*Note on the Parasite* (Temnocephala) *found on the Freshwater Crayfish of New Zealand.*

By CHARLES CHILTON, M.A., B.S.C.

[*Read before the Otago Institute, 11th September, 1888.*]

On both species of *Paranephrops* inhabiting New Zealand an ecto-parasite is found belonging to the genus *Temnocephala*, an aberrant monogenetic trematode. This has been mentioned by Wood-Mason,† who referred it to the typical species *T. chilensis*, Gay. Specimens were afterwards sent to Dr. W. A. Haswell, of Sydney, who has lately published a paper on the genus,‡ and he has given it the name *T. novæ-zealandiæ*. Similar species are found on other freshwater crayfish of Australia and Tasmania, each having its peculiar species of parasite, viz.,—

T. fasciata, on *Astacopsis serratus*; streams of New South Wales.
T. quadricornis, on *Astacopsis franklinii*; northern rivers of Tasmania.
T. minor, on *Astacopsis bicarinatus*; streams of New South Wales.

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* This is taken from a tracing kindly made for me by Professor Hutton from Dana's "Atlas," in the Canterbury Museum.

† "Ann and Mag. N.H.," ser. 4, xv., p. 336.

‡ "Q. J. of Micr. Science," xxviii., part 2, p. 279.

The New Zealand species I have found most abundant on specimens of *Paranephrops neo-zelanicus* from the Avon and Heathcote; but I have also found it on *P. planifrons* from Nelson, and I have seen its egg-cases on specimens of the same species from Napier and Greymouth. It is also found on Dunedin specimens of *P. neo-zelanicus*, but I have not noticed it on specimens of *P. planifrons* from Roto-iti, the Thames, and Manukau Harbour.

It should perhaps rather be called a *commensal* than a *parasite*, for it can scarcely derive any direct nourishment from the hard exoskeleton of its host: according to Haswell, it lives on small *Amphipoda*, and it is certainly capable of living for months away from the host, as is shown by the following fact: On the 14th September, 1885, some specimens of *Paranephrops neo-zelanicus* were brought to me with numerous specimens of *Temnocephala novæ-zealandiæ* adhering to them. I kept the crayfish alive in a glass jar till the 16th, when I put them in spirit, and during this time some of the *Temnocephala* detached themselves and moved on to some watercress and river-weed in the jar, and here some of them continued to live until the 16th January, 1886, just four months after they had left the crayfish. The specimen seen on this date appeared quite healthy and vigorous; but I lost sight of it, and did not see it again after that day.

ART. XXX.—*On some Gall-producing Insects in New Zealand.*

By W. M. MASKELL, F.R.M.S.

[*Read before the Wellington Philosophical Society, 17th November, 1888.*]

PLATES XI. AND XII.

A COMMON plant in gardens in this country is a native shrub—*Olearia furfuracea*—usually known to settlers by the name of aké-aké, though the true Maori name is aké-piro. It is a somewhat straggling bush with light-green leaves, the under sides of which are whitish; the leaves much "crimped." The flowers are small, yellowish, appearing in autumn, and have a faint scent resembling that of the lilac. The plant has no particular pretensions to beauty, but it grows fast to some ten or twelve feet in height, and is useful enough as shelter in a garden.

This *Olearia* is much subject to the attacks of a couple of minute insects, which, though they belong to two quite

different families of the class *Insecta*, the *Hymenoptera* and the *Diptera*, seem to have made common cause against the plant, and live in close alliance at its expense. A good deal of the straggling nature and ungraceful appearance of the shrub is due to their attacks, and doubtless if one could insure freedom from them the *Olearia* might be made much more ornamental than it is. Of these two insects, one, the hymenopter, preys apparently only on the buds and young shoots; the other infests both buds and leaves.

The "galls" produced on the plant are of two kinds. The one affecting the young shoots and buds has the appearance of large excrescences formed round the axils of the twigs, as if in those spots an abnormally large number of shoots had begun to grow out, and, having their growth suddenly arrested, had coalesced in an irregular mass, their stunted leaves crushed up and crowded together. Examples of these are shown in Plate XI., fig. 1, and Plate XII., fig. 1. It will be observed that there is a slight difference between these two, the leaflets in one being much smaller and more crowded than in the other. My experience has been that in the larger one (Plate XII.) only the *dipterous* insect lives; in the smaller one (Plate XI.) mostly the *hymenopterous*, but frequently, together with it, the dipteron also. A section of either of these galls will show (as in Plate XI., fig. 2) a colony of insects, in the pupa or in the larva stages, living in cells within it. The differences between the two insects may be easily seen by the larger size of the dipteron and therefore of its cell, independently of the differences of colour given below.

The other kind of gall is exclusively the work of the dipteron, and takes the form of blisters on the leaves, as shown in Plate XII., fig. 1, and in section, fig. 1*a*. When the perfect insect is ready to emerge it breaks a hole through the leaf, and the pupa thrusts itself out for about half its length before the fly emerges, as shown in the figure.

Of these two galls the last, on the leaves, would not probably be hurtful; the other, which arrests and deforms the growth of the young shoots, must exercise a baneful effect upon the vigour of the plant.

The two insects appear to go through their transformations and perform their work at the same periods of the year. The eggs are laid about October, and the larvæ emerge from them in a week or ten days. The larvæ seem to change to pupæ at different intervals—sometimes in early summer, sometimes not until the following spring. The perfect flies emerge about October, and probably, on any particular shrub, all about the same time. Procreation takes place immediately. I have seen a male and a female emerge from a gall almost at the same moment, and five minutes afterwards copulate.

The following descriptions of these insects are offered :—

ORDER. HYMENOPTERA.

Sub-order. TEREBRANTIA.

Family. CHALCIDIDÆ.

Genus **Eurytoma.**

Eurytoma oleariæ (Gall-fly of Ake-piro). Plate XI., figs. 1–16.

Insects inhabiting in the larval and pupal states, in colonies, excrescences and abnormal growths (galls) (figs. 1, 2) on the twigs of *Olearia furfuracea*. The galls are probably not produced by themselves, but by a dipterous insect. (See below.)

Larva (fig. 3) about $\frac{1}{16}$in. in length, grub-like, fleshy, yellowish; no true legs, but a number of very obscure tubercles; the head (fig. 4) exhibits a convoluted ring with two conical processes within it. On each joint of the body there are two minute circular spiracles (fig. 4).

Pupa (fig. 5) black, exhibiting the immature organs of the imago. The pupa is enclosed in a hard, grey case (fig. 5*a*), which has all the appearance of the dried larval skin. As coarctate pupæ are not, seemingly, found amongst the *Hymenoptera*, this case must be taken as an exceedingly closely-woven hard cocoon.

The perfect fly (fig. 6) is about $\frac{1}{12}$in. long; colour black, covered with short, fine, grey hairs; antennæ black; legs yellow; wings dark-grey. The head is transverse; eyes large; palpi short; thorax thick; mesothorax large and somewhat elevated; scutellum small. Abdomen (fig. 13) apparently composed of three parts—a short peduncle, a median cylindrical portion, and an oval hinder region with six or seven segments. The ovipositor of the female and the penis of the male are not usually exserted. Antennæ of both sexes (fig. 7, female; fig. 8, male) with twelve joints, of which the first two are very short, the third much the longest, the remaining nine sub-equal, each slightly dilated at the tip; all the joints except the two first hairy. The antennæ of both sexes are very similar: that of the female may be distinguished, perhaps, by being proportionately shorter than that of the male, and the joints after the third rounder. Feet (fig. 9) slender; the femur only moderately thick; the tibia dilated at the tip and bearing a spur; tarsus of five joints. The spur of the tibia on the two front legs (fig. 10) is peculiarly large, apparently cleft in the middle, with serrated edges; and the first joint of the tarsus has a distinct comb of stiff bristles on its inner side. The spur on the tibiæ of the other pairs of legs is a simple spine (fig. 11), and the tarsus bears no comb. Fore-wings (fig. 12) hairy, with very few veins; the sub-costal and anal

diverge almost at once, and extend a little within the margins for about half the length of the wing; at rather more than half their own length a conspicuous cross-vein unites them, and forms thus a triangular basal cell. The hind-wing has only one vein on the surface, the sub-costal extending for half its length and terminating at the two hooks on the edge. Both wings have faint patches of dark-grey on the surface. The exserted female ovipositor (fig. 14) has a somewhat thick cylindrical base, with a long, slender, curved tube, ending in a slightly-dilated bulb with three or four spines. The penis of the male (fig. 15) is long, cylindrical, with an oval terminal bulb, at the base of which is a ring of spines. The spermatozoa (fig. 16) are about $\frac{1}{3000}$in. long; they are wonderfully agile in their motions, and in the specimens observed retained their vitality for more than half an hour after extraction from the male insect.

This insect has been placed here in the genus *Eurytoma* of the family *Chalcididæ*, as it seems to agree better with that than any other, although not entirely satisfying the conditions. The veining of the wings appears to be more like that of some *Cynipidæ*, especially in the triangular basal cell; but the simple form of the abdomen removes it from that family, and the presence of the distinct segment between the peduncle and the true abdominal region approaches somewhat to the *Ichneumonidæ*. *Eurytoma* and its allied genera seem, indeed, to hold an intermediate position between the two families, and on this account the present insect has been assigned to that genus.

A point of importance remains to be considered. The *Chalcididæ* are not usually phytophagous, gall-producing insects, but parasitic on other flies; and it has always been a matter of doubt whether any of them depart from the rule. A species of *Eurytoma* is found to do much damage to wheat in America, producing on the stems galls which weaken and destroy the plant; yet it is not certain whether this fly (*Eurytoma hordei*) may perhaps not be only parasitic on a larva of *Cecidomyia*, and that this last larva may not be the real gall-producer. In the present case the galls of *Olearia* contain, as above stated, dipterous flies (described below), and these are *Cecidomyia*. Our *Eurytoma* may thus be merely a "messmate," to use Van Beneden's term, the dipteron being the real plant-enemy. That it is not a true "parasite" seems certain, as, although its larvæ and pupæ are found mixed indiscriminately with those of the *Cecidomyia*, they are in separate cells, and the *Diptera* in the leaf-blisters are never infested by them. On the whole, I incline to the belief that the *Cecidomyia* produces the galls on the twigs, and the *Eurytoma* takes advantage of them as a residence.

ORDER. DIPTERA.

Sub-Order. OVIPARA.

Family. CECIDOMYIDÆ.

Genus Cecidomyia.

Cecidomyia oleariæ (Blister-fly of Ake-piro). Plate XII., figs. 1–13.

Insects inhabiting, in colonies, excrescences produced by the larvæ on the young shoots of *Olearia furfuracea;* or, singly, blisters produced by the larvæ in the leaves of the same plant (figs. 1, 1*a*, 1*b*).

The eggs (figs. 2, 3) are elongated, pointed, red in colour, laid in bundles on the young shoots, usually in or near an axil.

Larva (fig. 4) white, becoming yellow before transformation; elongated, sluglike, footless; the head (fig. 5) has a simple flattish front with two curved claw-like processes, and two others, conical (perhaps rudimentary antennæ). There are only two spiracles, simple orifices, placed on the last segment of the body.

Pupa (fig. 6) naked; head-region black, abdomen red with blackish bands; immature wings and feet noticeable. On the head are four or five shortish bristles.

The perfect fly (fig. 7) is elongated and slender; head and thorax dark-red with large black patches; abdomen dark-red with black spots; legs dark-brown. The whole body and legs are covered with short hairs and with a number of black scales (fig. 13), pedunculate, something like those of *Lepidoptera;* these scales give the appearance of black bands to the abdomen—they are exceedingly loose, and apt to fall off at the least touch. The head is transverse; eyes conspicuous, almost covering the head; palpi long, four- (or five-?) jointed. Antennæ (fig. 11) in both sexes of fourteen joints, of which the first two are very short, the rest ovate and sub-equal, with hairs on each; in the female the last twelve joints are separated by short peduncles, which are not apparent in the male. Legs very long and slender (figs. 7, 12); the tarsi five-jointed, the first joint being very small. Wings (fig. 10) grey, with many short hairs on the surface and a fringe of long hairs on the edge; veins few and not anastomosed; the costal vein extends to the tip and meets the second longitudinal, the subcostal extending to about two-thirds of the length of the wing; the third longitudinal reaches the posterior margin at about half its length, and sends off a branch which extends nearly to the margin between it and the second longitudinal. Haltere (fig. 10) conspicuously long, with a large head. Abdomen of female ending in several short lobes, slightly turned

upwards (fig. 7); at rest, these are folded together (fig. 8); when opened (fig. 8*a*) two are long, cornute with sharp ends, and four others, shorter and tubercular, enclose a short cylindrical ovipositor. Abdomen of male ending (fig. 9) in two lobes; when exserted (fig. 9*a*) the penis is thick, cylindrical, somewhat dilated at the tip.

Length of the body about $\frac{1}{8}$in.; length of legs about $\frac{1}{6}$in.

In the venation of the wings this insect belongs to the true genus *Cecidomyia*, as defined by Osten-Sacken. In the genus *Diplosis*, which is near it, the second longitudinal vein curves downwards and reaches the margin of the wing below the tip. As regards specific distinctions, I have not sufficient material for complete comparison: possibly the presence of the curious and very loosely-attached black scales on the body may be a differentiating character.

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Plate XII.—*Cecidomyia oleariæ.*

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ART. XXXI.—*Notes on, and recent Additions to, the New Zealand Crustacean Fauna.*

By GEO. M. THOMSON, F.L.S.

[*Read before the Otago Institute, 8th November, 1887.*]

PLATES XIII. AND XIV.

THE notes in this paper serve partly to extend the range of many species hitherto recorded from only one or two localities in the colony; partly to call attention to descriptions of species new to our lists, but which have been described in foreign publications since the issue of the "critical list"* drawn up by Mr. C. Chilton and myself; and also to describe some new species. During the last four or five years a number of new forms of *Amphipoda* have been obtained; but, as the Rev. T. R. R. Stebbing, in his monograph of the "Challenger" *Amphipoda*, is revising all our hitherto-described species, I have thought it advisable to refrain from publishing any further additions to that group until his report has appeared.

In the following notes the numbers prefixed to most of the species are those of the "critical list" referred to.

Sub-order. MACROURA.

Hippolyte stewarti, n. sp. Plate XIII., fig. 1.

In the "Histoire Naturelle des Crustacés" (vol. ii., p. 377) M. Milne-Edwards describes a species of *Hippolyte* under the name of *H. spinifrons*, adding as its locality, "*habite les côtes de la Nouvelle-Zélande.*" Mr. Miers, in his "Catalogue of New Zealand Crustacea" (p. 80), quotes M.-Edwards's description, adding, "I have seen no specimens of this species." I have not met with any specimens either. But among the few shrimps obtained by the dredge in Paterson Inlet, Stewart Island, I obtained a very distinct species of this genus, with a characteristic rostrum, of which the following is a description:—

Rostrum springing about the middle of the carapace, and *reaching considerably beyond the peduncle of the inner antennæ, with 6 acute teeth on its upper and 2 on its lower margin*, which latter is greatly produced downwards in front of the orbit of the eye. The margin of the carapace under the orbit is furnished with 2 teeth, the lower and outer of which is most developed. The lower slender flagella of the internal antennæ are about as long as the carapace; the upper are much shorter. The scale of the external antenna reaches considerably beyond the extremity of the rostrum; (the flagella are missing in my

* "Trans. N.Z. Inst.," vol. xviii., p. 141.

specimen). The external maxillipedes, as in *H. spinifrons*, are very long, and reach considerably beyond the extremity of the scales of the outer antennæ. The legs of the 1st pair are moderately stout, and also reach beyond the extremity of the antennal scales; those of the 2nd pair reach to the end of the outer maxillipedes; the next three pairs are shorter. The abdomen narrows very suddenly at the last joint, and is bent completely round. The central caudal lamella has two spines on each side of the median line.

Length, about 1in.

Sub-order. Amphipoda.

5. *Corophium contractum*, Stimpson. Plate XIII., fig. 2.

When collecting on the shores of Auckland Harbour, between tide-marks, I picked up a small tube about 6mm. (¼in.) long, closed at one end and furnished with a hinged lid at the other end, which at the time I took to be the case of a marine caddis-worm. The tube was made of a very tough material, and was covered over with fragments of corallines; so that, had I not seen it moving, I should have passed it by without notice. On opening it the tube was found to contain a small specimen of *Corophium contractum;* but whether the crustacean constructed the tube, or, which is more likely, had merely found it empty and had taken refuge in it, could not be decided. Along with the amphipod was a small copepod (*Arpacticus*).

22. *Allorchestes neo-zealanica*, Dana. Plate XIII., fig. 3.

Found under stones between tide-marks in Auckland Harbour. The figure of this species in the British Museum Catalogue (pl. vi., fig. 8) is very poor and inadequate. The relative lengths of the antennæ in this and other species of the *Orchestidæ* appear to constitute characters of trifling importance from a specific point of view. In a single specimen dissected by me the peduncle of the anterior antenna is not nearly as long as its flagellum, and the latter organ is furnished with simple setæ, which are more than half as long as the joints which bear them. The posterior antennæ are very short, not exceeding the anterior in length. A very distinctive feature in the species is the form of the gnathopoda of the 2nd pair. The lower surface of the carpus (the margin of which is setose all round) is produced into a scoop-like projection, while that of the 1st pair is only slightly produced below. The meros of the 2nd pair is also produced below, but not into a scoop.

30. *Talorchestia tumida*, mihi. Plate XIII., figs. 4–8.

My original description of this species is reproduced by Mr. Stebbing in the "Proceedings of the Geological Society" (Lon-

don) of 19th January, 1886 (p. 4). Mr. Stebbing has very fully described and figured the male in the Transactions of the same society, vol. xii., p. 202, pl. xxxix.

The following is a brief description of the female:—

Mouth-organs as in male. Upper antennæ with the flagellum only 5-jointed; lower with the flagellum 12-jointed.

Gnathopod of the 1st pair (fig. 4) almost similar to the same limb in the male, but with fewer spines on the front margin of the first joint, and with the finger somewhat longer than the hand.

Gnathopod of the 2nd pair (figs. 5 and 6): First free joint nearly as long as all the rest together, with very numerous spines on the front margin, and almost smooth behind. Wrist and hand subequal in length, former rounded and slightly spinous below; hand laterally flattened, beset with short spines on both sides, with a produced rounded palm; finger almost obsolete, represented by a minute lobe at the extremity of the upper side of the hand. The three anterior pairs of peræopoda very similar to those of the male; those of the 4th pair having the 4th joint straight, with the front and back margins nearly parallel, and without the prominence so characteristic of some forms of the male.

34. *Megamæra fasciculata*, mihi.

Gathered in abundance at Waiwera and Auckland Harbour, mostly on the under sides of wet stones between tide-marks.

35. *Mæra sub-carinata*, Haswell.

Dredged in the Bay of Islands at 8 fathoms. Also received from Waipapapa Point, where it was gathered by Mr. J. F. Erecson.

39. *Melita tenuicornis*, Dana.

Found in abundance, along with No. 34, at Waiwera and Auckland; also dredged in the Bay of Islands, where Dana originally obtained it. It is a common littoral species.

41. *Harmonia crassipes*, Haswell.

A specimen, apparently referable to this species, was among my Bay of Islands dredgings, but the original description and drawing are so imperfect as to make identification difficult. It seems to me also that Mr. Haswell has not shown sufficiently good grounds for separating this species under a distinct generic appellation from Spence Bate's genus *Eurystheus*, to which I think it ought to be reunited.

43. *Aora typica*, Kröyer.

Very abundant in dredgings in the Bay of Islands. This is a very variable species. In one male specimen the right

gnathopod of the 1st pair was very greatly developed, that of the left limb being small and different in shape.

49. *Calliopius fluviatilis*, mihi.

This common fresh-water species has been found by Mr. Chilton at Anderson's Bay, in Dunedin Harbour, in brackish or nearly salt water, along with sea-anemones and other marine forms.

50. *Calliopius subterraneus*, Chilton.

I have received from Mr. W. W. Smith a specimen of this interesting form taken from a well at Ashburton.

52. *Pherusa cærulea*, mihi.

The preliminary description of this species occurs along with that of *Talorchestia tumida* in "Proc. Zool. Soc. London," of 19th January, 1886, p. 5. Mr. Stebbing's full description and figures are to be found in "Trans. Zool. Soc. London," vol. xii., p. 206, pl. xxxix.

54. *Dexamine pacifica*, mihi.

Very abundant in dredgings from the Bay of Islands.

55. *Phoxus batei*, Haswell.

One specimen dredged in the Bay of Islands.

56. *Panoplæa spinosa*, mihi.

57. *Panoplæa debilis*, mihi.

Both dredged in the Bay of Islands.

Family. Hyperiidea.

Hyperia (Tauria) macrocephala, Dana.

Two specimens collected at Sumner beach, near Christchurch, by Professor Hutton, and handed to me by Mr. Charles Chilton, are apparently referable to this species; but Dana's description and the figure given in the British Museum Catalogue (the only one accessible to me) are so imperfect that absolute identification is impossible.

While C. Spence Bate considers that the distinction on which Dana separated the genus *Tauria* from *Hyperia* depended merely on specific characters, Carl Bovallius, in his "Systematical List of *Amphipoda Hyperiidea*" ("Bihang till K. Svenska Vet.-Akad. Handlingar," band ii., no. 16), refers this species (p. 19) back to Dana's genus *Tauria* as *T. macrocephala*, but without any explanation of his reason for doing so.

This species has not been previously recorded from the colony, but may be expected to occur on our coasts from time

to time along with other pelagic South Pacific and antarctic species.

Hyperia dubia, n. sp.

A new hyperid, not referable to any described species, was picked up by my wife on the Ocean Beach, Dunedin. It was a female, carrying a large number of ova. Pending the publication of the "Challenger" report on the *Amphiphoda*, I have provisionally named this species *H. dubia*.

Sub-order. ISOPODA.

90. *Ceratothoa lineata*, Miers.

A single specimen of this species (which was previously unknown to me) was forwarded by Dr. Gaze, of Westport, who took it from the mouth of a guard- (gar- ?) fish at Nelson.

94. *Nerocila macleayii*, Leach.

Two specimens of this species (also previously unknown to me) were forwarded by the same correspondent, who informs me that they are common on kahawai (*Arripis salar*) and other large fishes on the west coast of this island.

Genus **Cassidina.**

In the absence of a copy of Dana's "U.S. Explor. Expedition," the following generic characters are taken from Milne-Edwards's "Histoire Naturelle des Crustacés," vol. iii., p. 223:—

Head large and very short, almost semi-lunar, deeply sunk into the thorax, produced anteriorly into a median process which is directed obliquely downwards between the bases of the antennæ. Eyes oval in form, occupying the lateral angles of the head. Antennæ and mouth-apparatus as in *Sphæroma*. Thoracic segments very large and prolonged on each side in the form of a thin plate, which is produced obliquely downwards and ends in an almost straight margin. The first segment of the thorax is produced forwards on each side of the head almost to the bases of the antennæ. Abdomen as wide as the thorax in front, but narrowing rapidly; it is divisible into two portions, the anterior of which is formed of several segments anchylosed in the median line, but separate at the sides, and the posterior scutiform portion. The ambulatory feet are slender and bi-unguiculate. The first five pairs of abdominal appendages are similar to those of *Sphæroma*, but have the margin of the external terminal lamella much more setose. The last pair of abdominal feet also resemble those of *Sphæroma*, only their terminal movable lamella is almost rudimentary, while the prolongation of the basal articulation

which represents the internal lamella is very large, and completely rounds off the abdominal shield.

Cassidina neo-zealanica, n. sp. (Pl. XIV., figs. 1–4.)

Body very flat, broadly elliptical in form, its breadth being almost exactly two-thirds of its length. Head as long as two anterior thoracic segments; the orbits of the eyes are produced a little back into the succeeding segment; frontal process pyriform, covering the bases of the antennæ. First and 2nd segments of thorax shortest in the median line, 3rd and 4th longest, remainder becoming shorter posteriorly. Abdomen about half as long as thorax; last segment triangular, obtuse, and (along with lamella of last caudal feet) thickly ciliated.

External (inferior) antennæ as long as cephalon and first three segments of thorax; peduncle 4-jointed, bearing several setæ, mostly all shorter than the diameter of the joints; 2nd joint rather the longest, 1st and 3rd subequal, shortest; flagellum 13-jointed, slightly longer than peduncle and tapering off to the extremity. Internal (superior) antennæ reaching to penultimate joint of peduncle of the external pair; peduncle 3-jointed, destitute of setæ, all the joints somewhat flattened, basal joint very broad; flagellum two-thirds as long as peduncle, 9- (10- ?) jointed, each joint bearing a jointed (olfactory ?) seta.

Internal lamellæ of caudal feet rather narrow, arcuate; external lamellæ oblong, obtuse, hardly more than one-fourth the length of internal lamellæ.

Colour brownish-grey, covered with black spots and star-like markings.

Length, 8mm.; breadth, 5mm.

Habitat. Creeping on kelp dredged from 10 fathoms in the Bay of Islands.

114. *Cleantis tubicola*, mihi. (Pl. XIV., figs. 5–8.)

The following is a short description of this species, of which only a preliminary notice in the "New Zealand Journal of Science" (vol. ii., p. 577) has hitherto appeared.

Body narrow, much elongated, with the sides perfectly parallel. Cephalon with its lateral margin produced downwards into an angular lobe; its front margin nearly straight (transverse); its posterior margin produced backwards in the middle into an excavation of the first thoracic segment; eyes rather narrow, placed near the sides of the head. First thoracic segment subequal in length to the cephalon; 2nd rather shorter; succeeding segments subequal, hardly exceeding the 1st in length. Epimera of first four segments indis-

tinct; those of the 5th, 6th, and 7th segments distinct, and with their exterior margins produced backwards.

Abdomen about 4mm. long; the rest of the body being 11mm.; 2nd segment rather indistinct; last segment as long as the first five segments of body, and ending in a deep semicircular notch. The operculum is crossed by a transverse line about one-third of the length from the extremity.

External antennæ thick and pediform, as long as the cephalon and three succeeding segments; peduncle 4-jointed, flagellum 2-jointed, joints diminishing in length towards the end. Internal antennæ reaching to the end of the second joint of the external pair; peduncle 3-jointed; flagellum with one long joint, ending in a very short joint and a tuft of setæ.

Length, 15mm.; the ratio of length to breadth being as 11 to 1.

Colour brown, with minute black punctations.

116. *Jæra neo-zealanica*, Chilton.

This species, Mr. Chilton informs me, is identical with Dana's *Jæra pubescens*, from Tierra del Fuego. The description and figure of that species, however, leave this identification somewhat doubtful. Meanwhile C. Bovallius* separates those species with tri-unguiculate dactyla into a new genus *Iais*, of which the following is the generic character:—

Genus **Iais**, Carl Bovallius.

"Body depressed, elongate. Head rounded, not rostrate. Eyes small, consisting of very few ocelli. First pair of antennæ few-jointed. Second pair longer than half the body, with multi-articulate flagellum. Mandibles provided with a 3-jointed palp. Lateral margins of the pereional segments scarcely produced, not covering the bases of the legs. Pereiopoda subequal, walking legs; dactyli pedunculated, 3-unguiculate. The uropoda consist of thick cylindrical peduncles, and two elongate laminate rami."

Iais neo-zealanica, Chilton.

Numerous specimens of this species were taken by me between tide-marks in Auckland Harbour.

118. *Janira longicauda*, Chilton.

This species differs from *Janira* and allied genera sufficiently, in the opinion of Carl Bovallius, to be separated into a new genus *Iathrippa*,† of which the following is the character:—

* "Notes on the Family Asellidæ" ("Bihang till K. Svenska Vet.-Akad. Handlingar," band ii., no. 15, p. 50).

† *Loc. cit.*, p. 61.

Genus **Iathrippa**, C. Bovallius.

"Body depressed, elongate. Head large, provided with a rounded rostrum. Eyes large, facetted. First pair of antennæ short, shorter than the breadth of the head; flagellum multi-articulate. Lateral margins of the pereional segments feebly produced, incised, scarcely covering the bases of the legs. First pair of pereiopoda subcheliform (?); the following subequal walking legs. Dactyli bi-unguiculate. Uropoda dilated; the rami long, laminiform, lanceolate."

Only species, *Iathrippa longicauda*, Chilton.

136A. *Armadillo ambitiosus*, Budde-Lund.

This species was originally described in the "Prospectus generum specierumque Crustaceorum Isopodum terrestrium" (Copenhagen, 1879). The following somewhat abbreviated description is taken from the same author's "Crustacea Isopoda Terrestria" (1885), p. 34:—

"Oval oblong, strongly convex, nearly smooth but minutely punctate.

"Antennæ (?). Eyes large, with about 20 ocelli. Epistome with its superior margin reaching a little beyond the front at the sides, but not in the middle. Clypeus with medium-sized lobes.

"First thoracic segment with a thin lateral margin, and with a small tooth on the inside of the posterior portion (?). Second segment with the lateral margin entire, thickened in front; posterior margin of the first (few) segments distinctly sinuate on both sides.

"Anal segment longer than broad, somewhat contracted in the middle, apex truncately rounded. Basal joint of the anal feet one and a half times (or more) as long as broad, narrowing greatly towards the apex; external branch small but conspicuous; internal branch shorter than the last segment.

"Colour nearly uniform brown.

"Length, 14mm.; breadth, 7mm.; height 3·5mm.

"*Habitat.* New Zealand; a single defective specimen preserved in the Cambridge Museum, Mass. (U.S.A.)."

Unfortunately, no figures of this species are given.

In the same work, p. 46 ("Crust. Isop. Terrestr."), Budde-Lund describes another new species belonging to the section *Armadilloidea*, under the name *Cylloma oculatum*, this being the only species of the genus. The following is his description of both genus and species:—

Cylloma.

"External antennæ (?). Internal antennæ with the first joint very short, third very long and straight. Eyes com-

pound, very large, prominent, situated in oval cavities; ocelli about 150, disposed in four or five rows. Clypeus nearly perpendicular, not lobed on the sides. Epistome forming a continuous frontal marginal line. Epimera of the front segments of the thorax with their posterior portions entire. Anal segment of the tail very short, broadly subtriangular. Exterior ramus of all the pairs of caudal feet furnished with tracheæ.

"*Cylloma oculatum*, Budde-Lund.

"Oblong oval, nearly smooth. Epistome with a triangular tubercle below the middle, with its superior margin reaching very much beyond the middle and somewhat reflexed. Vertex between the eyes obliquely 2-wrinkled.

"First thoracic segment with its anterior margin roundedly produced in the middle, curved; its posterior margin distinctly sinuate on both sides; lateral margins thickened (sub-altecinctis?), entire behind; posterior angles produced backwards. Third and fifth abdominal segments with large epimera, greatly produced backwards; epimera of the fifth segment suboval, somewhat convergent. Caudal feet greatly exceeding the anal segment; basal joint subtetragonal, its exterior portion toothed, shorter than the penultimate segment; external terminal ramus inserted on the inner portion of the basal joint, and slightly exceeding the epimera of the penultimate joint.

"Colour uniform, brown (?).

"Length, about 10mm.; breadth, 4mm.; height, 2·5mm.

"*Habitat.* New Zealand. Described from one very imperfect specimen preserved in Cambridge Museum, Mass. (U.S.A.)."

In the absence of figures, the descriptions of these two species, neither of which is known to New Zealand naturalists, and which are confessedly based on single imperfect specimens, are somewhat unsatisfactory.

DESCRIPTION OF PLATES XIII. AND XIV.

PLATE XIII.

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PLATE XIV.

Fig. 1.	*Cassidina neo-zealanica*, dorsal view	.. .. ..	× 6
Fig. 2.	„ inner antennæ	.. ..	× 20
Fig. 3.	„ outer antennæ (*f.p.* = frontal process; *e.* = epistome)	... .	× 20
Fig. 4.	*Cassidina neo-zealanica*, end of 4th leg	.. ..	× 40
Fig. 5.	*Cleantis tubicola*, dorsal view	.. ..	× 8
Fig. 6.	„ lateral view, to show the epimeræ	..	× 6
Fig. 7.	„ inner and outer antennæ	.. ..	× 26
Fig. 8.	„ abdomen, viewed from under side	..	× 13

III.—GEOLOGY.

Art. XXXII.—*The Earthquake in the Amuri.*

By Professor Hutton.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1888.*]*

Plates XV.-XVII.

The earthquake that took place on Saturday, the 1st September, 1888, was felt from Invercargill in the south to New Plymouth and Masterton in the north, a distance of about six hundred miles, but was most severe in the neighbourhood of the Hanmer Plains, which are nearer to the northern limit of the disturbed area than to its southern limit by about fifty miles. The shock commenced soon after 4 a.m., with a rumbling noise and slight shakes for a second or two, followed by the main shock, lasting from forty to sixty seconds, or even more in some places. Judging from my own feelings at Christchurch, I should say that the shock was a backward-and-forward oscillation that began gradually and as gradually died away after about forty-five seconds' duration, and that it was not accompanied by any sharp jerks. It was followed within the next quarter of an hour by two much smaller shocks, while other slight ones occurred continually until 5 or 6 a.m., these slighter shocks being only felt in the Amuri, at Boatman's, Reefton, and Westport. All Saturday, Sunday, and Monday the ground at the Hanmer Plains was quivering; with smarter shocks, felt on the west coast and at Christchurch, at about 3.55 a.m. and 4.25 p.m. on Saturday, at 11.15 a.m. on Sunday, and at 8·15 a.m. on Monday. At Westport small earthquakes occurred almost every day for a fortnight; at Reefton every day for nine days; while in the Hanmer Plains they were tolerably frequent up to the end of the month, with heavier shocks, felt on the west coast and at Christchurch, on the 9th and 28th September, and again on the 12th October. A slight shock was felt in the Amuri on the 28th October, and another at about 11 a.m. on the 13th

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* A rough draft of this paper was read on 6th September, 1888, but it has been added to and revised up to 20th November, 1888.

November. It lasted for thirty or forty seconds, and was an easy, swaying kind of movement.

On Thursday, the 30th August (that is, before the main earthquake), a shock occurred at a few minutes past 10 p.m. which was felt from Hokitika and Westport, on the west of the island, to Christchurch and Kaikoura, on the east; but it was not severe at the Hanmer Plains, and the time-observations indicate that it originated more to the south—probably in the Upper Hurunui. Another sharp earthquake took place at about a quarter past eight on the morning of the 23rd October; but this was more severely felt at Nelson, and the time-observations show that it certainly originated north of the Hanmer Plains and probably in the neighbourhood of Mount Owen. Still another but slighter shock on the 28th October was, according to Mr. A. McKay's report, felt more severely at Kaikoura than elsewhere. At any rate, none of these shocks originated from the same place as that of the 1st September.

At the time of the shock it wanted just five days to the new moon. The weather was fine and cold, a sharp frost being felt at Hanmer Plains. Over the north-west portion of the island, from Nelson to Hokitika and Bealey, the barometer was slowly rising; at Lyttelton it appears to have remained steadily at 30·45 from 9 a.m. on Friday to 9 a.m. on Saturday; while at Kaikoura it fell slightly, from 30·44 at 5 p.m. on Friday to 30·41 at 9 a.m. on Saturday. The self-registering barometer at the Agricultural College, Lincoln, was falling from 30·70 at 1.30 a.m. to 30·45 at 2 p.m. on Saturday, the height at the time of the earthquake being 30·65. The sky is reported as clear and star-lit. The air was nearly calm in the interior, and with a slight easterly breeze on both coasts, changing to north-west at Bealey. The humidity of the atmosphere at 9 a.m. on Saturday is given at 92 at Nelson, 63 at Bealey, and 41 at Tophouse in the Upper Wairau. The shock, therefore, appears to have been quite unconnected with the weather or with the position of the moon.

Description of the District.

The watershed of the New Zealand Alps is here formed by the Spencer Mountains, from Mount Franklin in the north to the Hurunui Saddle and Arthur's Pass in the south. It lies at a distance of about twenty-five miles north-west of the hot springs on the Hanmer Plains. Between Mount Franklin and the Hurunui Saddle the range is broken by three low passes called Cannibal Gorge, the Amuri Pass, and the Hope Saddle; and it lies almost exactly half-way between the east and west coasts of the island, which is here about 110 miles broad. Both east and west of the watershed the country is mountainous, undulating hills and plains being rare.

The main range of the Spencer Mountains is formed by contorted sandstones and slates, which to the west are followed by a narrow band of micaceous schists. Beyond these granite forms a range called the Victoria Mountains, which is parallel to the Spencer Mountains. East of the Spencer Mountains, much-jointed sandstones and mudstones form the lower ranges surrounding the Hanmer Plains, the only known eruptive rock being a small syenite boss at Hurunui Peak and the Mandamus River. These sedimentary rocks are of carboniferous and triassic age, some, perhaps, being jurassic. Bordering them on the north side of the Hurunui Plains, and stretching north-west towards Kaikoura, tertiary limestones, sandstones, and clays are found, which are of oligocene and miocene age, and amoug them volcanic rocks, not younger than miocene, occur in three places—(1) Where the River Pahau enters the Hurunui Plain; (2) at Lyndon, about nine or ten miles due east of Hanmer Hot Springs; and (3) up the Mason River, on the Highfield Station, about five miles east of the last.

The Hanmer Hot Springs occur on a clay terrace on the north side of the plain, and are at a height of about 1,200ft. above the sea. There are ten springs, two of which are cold, the rest warm; the hottest having a temperature of about 117° F. In cutting a ditch for laying pipes to take away the overflow from the baths, a layer of black peat, some 6in. or 7in. thick, with tough clay on each side, was found. This layer would pass about 10ft. or 11ft. under the bath-house, and probably some 15ft. below Spring No. 1. One of the springs (No. 9) often brings up small fragments of this peat; so that it probably spreads under the whole. Complete analyses have been made of the water from three of the hot springs by Professor Bickerton. They are all alkaline. The salts in the springs are chiefly sodium-chloride, but in addition there are alkaline sulphates and carbonates in about equal quantities. The ammonia and albuminoid ammonia are no doubt derived from the layer of peaty matter which the waters pass through; and, no doubt also, this organic matter reduces part of the alkaline sulphates to the condition of sulphides, which are decomposed by the action of carbonic acid derived from the peat, and changed into alkaline carbonates with the disengagement of sulphuretted hydrogen: some of the latter may, however, be derived from the albuminoid ammonia. The passage of the water through the peat-bed is too rapid to allow of the whole of the sulphates being changed into carbonates; but in all probability no carbonates and no sulphuretted hydrogen, and certainly no ammonia, exist in these waters below the peat-bed. The heat of the water makes these reactions go on energetically, but the reactions

do not themselves give rise to sufficient heat to heat the water. The water must be hot before it reaches the peat-bed.*

I mention these details because it has been supposed that the presence of sulphuretted hydrogen in these springs indicates the presence of volcanic energy below the Hanmer Plains, which has been supposed to be connected with the origin of the earthquake.

Other hot springs occur in Cow Creek, a branch of the Edwards River;† in Cannibal Gorge; in the Upper Hope; in

* The following are the analyses (referred to on p. 271), which have not before been published:—

—	Grains per Gallon.		
	Spring No. 1.	Spring No. 7.	Spring No. 8.
Specific gravity at 60° F.	100064	..	100108
Sediment (silica and free sulphur) ..	3·15	..	1·4
Ammonia, free	0·156	0·198	0·112
" (albuminoid)	0·44	0·016	0·058
Potash	1·68	1·47	1·06
Soda	34·83	31·61	32·38
Lithium	Trace	..	Trace
Lime	1·72	0·70	4·11
Magnesia	0·07	1·00	0·17
Iron	2·52	0·25	0·26
Alumina	0·08	0·07	0·08
Carbonic anhydride	5·39	3·69	5·23
Sulphuric "	4·69	10·42	7·00
Nitric "	0·139	..	0·215
Phosphoric "	Trace	Trace	Trace
Chlorine	35·78	33·60	34·29
Sulphuretted hydrogen	3·29	?	3·43
Bromides and iodides	nil	nil	nil
Total	93·885	83·019	89·745
Deduct oxygen equivalent to chlorine	8·06	7·57	7·72
Grains per gallon	85·825	75·449	82·025

† Analysis made in the Colonial Laboratory, Wellington, of incrustations from the hot springs at Cow Creek, Edwards River, Amuri District, forwarded by Professor Hutton, November, 1888:—

Nos. 1 and 2 are pure alum, which has a sweetish astringent taste, and is entirely soluble in water.

No. 3 is a dark pitchy substance, having a disagreeable pungent odour. The following is the result of a partial analysis of it:—

Organic matter	16·00
Sulphur (free)	16·25
Iron-oxide	13·00
Sand and clay	36·00
Water	18·75
	100·00

the Upper Hurunui; and in the Otira Gorge; in all cases lying in the old sedimentary sandstones and slates. The waters of these have not been analysed, but Mr. F. Stephenson Smith, who surveyed the district, informs me that the Cow Creek hot springs issue from the solid rock, which is coated over with a red deposit. The temperature at the point of issuing from the rock was 135° F. The temperature of the Hurunui springs is 139° F. The Cow Creek springs are said to smell of sulphuretted hydrogen like those at Hanmer Plain, as also do those in the Otira.

Evidently none of these hot springs are connected with the miocene volcanic rocks of Lyndon or the Pahau, but owe their heat, in all probability, to the crushing of rocks under the mountains.

It was in this district, known as the Amuri district, that the principal force of the shock was felt. It is thinly inhabited, and is bounded on all sides but the south for a distance of from thirty to ninety miles by country which is almost or quite uninhabited; large parts being mountains, which on the western side are covered with dense forest. Under these circumstances we cannot expect to obtain a full knowledge of the nature of the earthquake or the position of the centrum; but, at the request of the Council of the Institute, I have put together all the reliable information that I have been able to obtain. On the east side of the Alps we have very good reports from newspaper correspondents and especially from Mr. A. McKay, Assistant Geologist, and as soon as I could leave Christchurch I paid a visit myself to the Hanmer Plains. From the west coast I have been most liberally supplied with copies of the newspapers published at Greymouth, Reefton, Westport, and Lyell; and from these as well as from other places I have received information from many people in reply to a circular that I sent out; and Mr. McKerrow, Surveyor-General, has supplied me with some excellent maps of the district.

DAMAGE DONE TO BUILDINGS.

Amuri District.

Glynn Wye.—The manager's house, a wooden building, was pushed several degrees out of the perpendicular to the east, and the chimneys were thrown down. The men's cottage, also wood, was shifted bodily 15in. to the north. The wool-shed was also much damaged.

Hopefield.—Chimneys thrown down and roof twisted out of shape.

Jones, Waiau Station.—Woolshed and house badly damaged. Men's cob hut destroyed.

Woodbank.—Partly brick and partly wood. The brick portion, which was very old, had two walls thrown down. The wooden building was not much damaged, but shifted bodily 2½in. to the east. The chimney fell to the west. A concrete chimney between the two parts of the house was broken off at the roof, and the upper portion was thrown upwards and fell to the east. A cob hut has the south-west corner knocked out; the west end would have fallen, but was held up.

Hot Springs.—No damage was done; but the only chimney is low, and of concrete.

Jack's Pass Hotel.—No damage done, and very little breakage of glass.

St. James'.—Chimney-tops fell on earthquake of the 28th September; but it is thought that they were cracked through by the shock of the 1st September, but did not then fall.

Jollie's Pass Hotel.—No damage done, and very little breakage of glass.

St. Helen's.—The three chimneys were thrown down. They fell in different directions. Hams were thrown off hooks, as also was a birdcage.

Ferry Hotel, Upper Waiau-ua.—This is an old cob building, but it was not much damaged.

Tekoa.—A brick house. The upper portions of the walls fell, it is thought because they were not so well built as the lower portions.

Balmoral.—No damage reported.

Culverden.—At the station three or four chimney-pots fell. At the township no damage is reported.

Montrose.—The tops of two chimneys fell.

Leslie Hills.—A stone building. The walls were cracked in various directions, and the five chimneys fell, the north-west portion being the most damaged. The old building with cob walls, in very good condition, stood better than the stone. The men's hut, ten chains from the house, and built of cob, received no damage—even an old chimney, partly cob and partly brick, was not injured.

Lyndon.—A chimney was thrown down.

Waiau Township.—Several chimneys were thrown down, and a granite monument in the cemetery was overturned. It was a pyramid standing on a granite base. The pyramid only was overthrown.

Highfield.—Three chimneys fell. An outside one was completely wrecked; the two inside ones were broken off at the roof. They fell in three different directions.

Kaikoura.—One or two chimneys were thrown down, and others were cracked.

Canterbury District.

Waikari.—Two chimneys were overthrown.

Amberley.—No damage reported.

Rangiora.—A few bricks were thrown from the top of a chimney. Some crockery was thrown down and broken.

Kaiapoi.—The tops of two or three very old chimneys were thrown down. The woollen-factory chimney was uninjured.

Christchurch.—The most noticeable damage was to the Cathedral spire, the upper 26ft., with the cross, having been shaken down. An eye-witness says that his attention was called to the spire by the ringing of the bells (which had been set overnight for ringing); he then saw three or four stones shoot out, after which the top part of the spire swayed for a second or two; and then, after the chief violence of the shock was over, the top, with the cross, fell to the north. No other injury was done to the Cathedral, nor to the spire below the 26ft. that fell. The cross, which was of solid iron, was fastened to an iron bolt which passed through 18ft. of solid masonry, and had an iron plate a foot square at the bottom, the whole weighing not less than 60 tons. Below this the spire was hollow, and from the iron plate four iron stays 16ft. long were carried down inside the spire and secured to iron plates fastened in the masonry. The top of the cross was 210ft. above the ground. It is generally thought that the spire would not have been damaged if the top had not been solid, and if it had not been so firmly tied down.

In the Normal School the top of one of the chimneys was shaken down, and four others were split. The East Christchurch school had some of the chimney-tops much shaken, and some chimney-heads fell. The Wesleyan Church was much shaken, and some of the stones moved out of their places. Three chimneys in private houses also fell. A few other buildings were slightly damaged. None of the factory-chimneys were damaged, although that of Scott and Co. is about 80ft. high, and has an iron railing weighing 2 tons on the top. Very little, if any, glass or crockery appears to have been broken. None of the specimens in the Museum were hurt. In the East Belt the main sewer was cracked; but it here passes through a quicksand, and great difficulty was experienced in making it. At Avonside Church the stone cross on the northern gable of the transept was thrown down. A few chimneys were also injured at Avonside, Heathcote, and Linwood.

Lyttelton.—No damage was done. The water in the harbour was not disturbed.

Ashburton.—The roof of the Borough School was split, and the plaster shaken down.

No damage is reported from other parts of Canterbury.

Nelson District.

Nelson.—No damage done. A few bricks are said to have been dislodged from the top of a chimney, but this has not been confirmed.

Maruia Plains.—The *Reefton Guardian* says that it is reported that the effects of the earthquake were of a very serious nature at Walker's station, in the Maruia, but I have not been able to learn anything more about it.

Lyell.—No damage was done.

Westport.—No chimneys were thrown down, but two in course of erection were cracked. No damage was done to the lighthouse at Cape Foulwind. There was no sea-wave.

Boatman's.—No damage done.

Reefton.—No chimneys suffered, but some glass and crockery was thrown from shelves and broken. The shock was severely felt by miners in the Progress Mine: the timbers creaked, and strange noises issued from the ground.

Greymouth.—Several old and badly-built chimneys fell. They seemed, from the indications on the mortar, to have been screwed off from the north-east towards the south, in some instances showing signs of quite a third of the arc between the two points mentioned. The greater portion of the bricks fell on the southern sides of the chimneys. The tall brick chimney of the engine-house of the hydraulic cranes was uninjured, as also was the Catholic church. A good deal of glass and crockery was thrown down and broken. In the teacher's house at Dunganville the school-register was thrown a considerable distance a little south of west.

The shock is stated to have been more severely felt in the inland districts. There was no sea-wave.

Hokitika.—Chimneys were thrown down in the Odd Fellows' Hall and Police Camp, and several others were cracked. There was no sea-wave.

The conclusions that may be drawn from this statement of facts are—(1) that, except in the neighbourhood of the centre of impulse, the only damage was to buildings put up with bad mortar, or faulty in construction; (2) that cob stands the shock better than brick or stone with bad mortar; and (3) that houses on alluvial gravels, &c., suffered more, *pari passu*, than those on solid rock. Other points connected with this part of the subject will be considered further on.

Fissures, Landslips, etc.

These were formed chiefly in the valleys of the Hope and Waiau-ua Rivers. On the Hanmer River there were a few small cracks near the edge of the terraces, and a few others on an island in the bed of the Percival: all these appear to

have been filled up again before November. Small landslips occurred in the cutting leading to the bridge over the Waiau-ua, and two larger ones at the approach to the ferry. Up the Waiau-ua no fissures are reported until opposite the Grantham River, where there are some cracks 4in. or 5in. wide. From here, along the south side of the river, they get more and more abundant to Hopefield and Glynn Wye, but were seldom more than a foot in breadth, the larger ones being generally near the river. On the flat of Shingle Creek there were several fissures 4in. to 6in. wide. A large fissure was reported at the back of the house at Hopefield, and two circular holes about 4ft. in diameter and several feet deep are said to have been formed near Glynn Wye. Near this place fissures were very numerous in the terraces, some being more than a foot wide. Up the Hope they were still larger, some being more than 2ft. broad and several feet deep. Wire fences on the terraces were moved in places from 5ft. to 8½ft. horizontally. All these fissures were in alluvial deposits, and were more or less parallel to the valley of the Hope and Waiau-ua Rivers. Above the junction of the Boyle with the Hope the fissures get smaller and less numerous and more confined to the edge of the terraces, but there are numerous landslips on the sides of the mountains. Beyond Kiwi Creek no fissures have been noticed in the valley of the Hope, but some continue up the alluvium of Kiwi Creek. None are reported in the valley of the Boyle, and none in the Waiau-ua above Hopefield. As a glance at the map will show, all these fissures are confined to the alluvial deposits; none have been detected in solid rock.

At Tekoa Station, on the Mandamus River, numerous and large blocks of rock fell from the cliffs, making a great noise.

In the Bealey several landslips occurred, and in the Otira Gorge part of the road slipped down. At the accommodation-house at the entrance to the Otira Gorge the shock was felt very severely. Stones and rocks rolled down the mountain-side in great numbers, striking each other and leaving long trains of fire behind them—a phenomenon which has been observed before in landslips. A large fissure was formed in Kelly's Creek, but I have not been able to obtain any particulars about it.

A miner from the Totara Flat District, between Greymouth and Reefton, reports that a number of trees on both sides of his claim were thrown down; and this was probably due to slips. A shepherd who was in Jones's hut, in the Upper Hope, also reported that dead branches were shaken from the trees, and it appears that many dead trees were also broken off about 10ft. from the ground, some at least a foot in diameter. In some places near here green trees 25ft. to 30ft. in height have been torn up by the roots; and this was probably due to slips.

None of the hot springs were permanently altered, although those on Hanmer Plains were much agitated, became muddy, and emitted more gas, but with no extra flow of water. By the 5th September they were merely discoloured, and they gradually got quite clear again. Sulphuretted hydrogen escaped from the ground in many places near the hot springs; and it was reported that it escaped from other places on the plain, but there is no evidence of this. A small opening was made close to the swimming-bath, which spouted out mud and gas, with very little water, for the three days that the ground was in constant movement.

All these phenomena appear to me to be secondary effects of the earthquake—that is, they were not the cause of the shock, but were produced by the reaction of the earth-wave in its propagation through the earth. Fissures which are more or less parallel to some superficial feature of the surface must almost certainly be themselves superficial; and fissures which are confined to alluvial deposits must almost certainly have originated in those deposits. They can, I think, all be explained by the principles laid down by Oldham and Mallet in their paper on the earthquake in Cachar of 1869.*

Probable Position of Epicentrum.

There are three different kinds of evidence which will help us to find the probable position and shape of the epicentrum:—

(1.) The intensity of the shock in different places.
(2.) The direction of the shock in different places.
(3.) The time the shock was felt at different places.

The first kind of evidence will give us true results so far as it goes, and when an earthquake has originated in a well-populated and civilised country this method can be relied on; but when an earthquake originates under the sea or in a thinly-inhabited district it cannot lead to very accurate results. The second and third kinds of evidence are liable to many sources of error; but if all erroneous observations could be eliminated, the remainder would give a much closer approximation to the truth than can, in the cases supposed, be got from the first kind of evidence.

In our case the earthquake originated in a district not only very thinly populated, but one very difficult to examine—so much so that the only accurate observations that have been made are along one line—from west to east; all the country to the north, west, and south of the place of origin being as yet unexamined. This being so, it is obvious that

* "Quarterly Journal of the Geological Society of London," vol. xxviii., p. 255.

observations on the intensity of the shock cannot do more than give us a rough approximation to the position of the epicentrum; nevertheless, this approximation, although rough, will be undoubtedly correct so far as it goes, and will thus enable us to discard evidently erroneous observations of the second and third class of evidence. I shall therefore begin with the evidence of the first class.

Intensity of the Shock at Different Places.—The intensity of shock can be roughly estimated by the damage done to buildings, or to glass and crockery on shelves; but great anomalies occur locally (which will be considered later on), and it is only by taking a comprehensive view that we can arrive at any results. There is no difficulty in concluding that where wooden houses have been wrenched out of shape the shock has been more intense than where chimneys only have suffered. But there are great differences in chimneys—in proportions, in supports, in construction, and in materials—and we cannot make any close comparison between them. Bottles and crockery on shelves are, however, under more similar conditions, and afford a better comparison than chimneys in estimating the relative intensity of the shock. Fissures and landslips also afford good evidence when the conditions are tolerably equal.

From the record of facts already given it will be seen that Glynn Wye, on the River Hope, appears to have sustained the greatest shock. It is the only place where wooden houses have been wrenched out of shape; and here the fissures and landslips are greater than elsewhere.

Glass and crockery were thrown off shelves at Waikari, Rangiora, Reefton, Westport, Greymouth, Marsden, Notown, Kumara, and Hokitika, all being within a radius of seventy miles from Glynn Wye.

Chimneys were thrown down or damaged at Kaikoura and Christchurch, within a radius of eighty miles of Glynn Wye; and slight damages are reported from Ashburton and Nelson, each about a hundred miles from Glynn Wye.

At further distances no damage was done to buildings. The greatest damage, however, does not take place at the epicentrum, where the shock is vertical, but where the direction of the wave makes an angle of between 55° and 45° with the horizon; consequently the position of the epicentrum would probably be somewhere to the west of the meridian of Glynn Wye; and Mr. O. Thompson, the manager, says that the shock passed to the eastward, down the valley, with a hoarse crashing sound which gradually died away in the distance, while things were quiet at the place where he stood. At Reefton no chimneys were thrown, so that the shock there must have been less than at the Hanmer Plains. This may have

been due in part to the intervening ranges of mountains, but it prevents us locating the epicentrum very far west of Glynn Wye.

If we assume that the meizoseimic band extended three miles on either side of Glynn Wye, and that the angle of emergence was 55° on the western edge of this belt and 45° on the eastern edge, it would indicate that the epicentrum was about seventeen miles from Glynn Wye, and about twenty miles below the surface.

Mr. A. McKay, in his report, says that he is of opinion that the shock "commenced at some point to the west of Glynn Wye, perhaps further west than the junction of the Kiwi with the Hope, and that it travelled eastward with increasing force to Glynn Wye and Hopefield, beyond which places, by what appears at the surface, its destructive character began to be less." The junction of the Hope and the Kiwi is fourteen miles west of Glynn Wye.

Direction of the Shock at Different Places.—Reports under this head vary extremely, even from the same place, and in the absence of seismographs no accurate results can be expected. It is known from observation that the normal wave is followed by a transverse wave, and that afterwards the ground oscillates irregularly; so that, even if the direction be estimated right, it would be impossible to distinguish the normal from the transverse wave. Even accurate observations may often give a wrong direction. For example: The movement of cream in a pan at Rangiora gave S.W. and N.E. as the direction. At Ohoka the same kind of seismometer registered the shock as E.S.E. and W.N.W. At Ashburton a lamp was seen to swing east and west. In Christchurch water was thrown out of buckets in different directions in the same building, although in the majority of cases it was to the N.W. In fact things in general seem to have been thrown away from a wall without much reference to the shock. In the Canterbury Museum some unsupported table-legs in the Indian case fell to the east; but I found that the shelf on which they stood had a slight slope in this direction. All these and many others must be rejected as pointing far out of the direction of the normal wave; and, indeed, but little weight can be attached to this kind of evidence at all: but, as it is quite independent of all other evidence, it may be worth while to find out what results it leads to.

At Wellington the seismograph is reported in the newspapers as registering the shock N.E. and S.W.; at Christchurch the cathedral-spire is octagonal, and the cross fell over to the side facing N.W. This no doubt shows roughly the true direction of the shock, but it might have come from any point between W.N.W. and N.N.W. I will take it at N.W.

The other places from which I have records pointing more or less in the true direction are—Greymouth, E. and W.; Notown, S.E. to N.W.; Westport, S.E. to N.W.; Reefton, S.E. to N.W.; Boatman's, first shock E. and W., second S.E. to N.W.; Lyell, S. to N., or S.E. to N.W.; Nelson, S.W. to N.E.; Blenheim, S.W. to N.E.; Kaikoura, N.N.W. to S.S.E.; Waikari, N. and S.; Leeston, N. and S.; and Kirwee, N. and S.; or fourteen stations in all. I have also ten other stations, in which the directions given are too wide of the mark to be of any use. They are—Rangiora, S.W. to N.E.; Ohoka, E.S.E. to W.N.W.; Ashburton, E. and W.; Lauriston, S.E. to N.W.; Glentunnel, E. and W.; Timaru, between W. and N.; Queenstown, N.W. to S.E.; Dunedin, E. to W.; Invercargill, W. to E.; Manaia, S. to N. (nearly correct).

If we project the fourteen fairly accurate directions on a map, and then describe the smallest circle possible which will touch or cut all the lines, it comes out that the circle has a radius of about thirty miles, and its centre is situated at the Amuri Pass, at the head of the Doubtful and Ahaura Rivers, about seventeen and a half miles W.N.W. of Glynn Wye. This approximation is nearer the truth than could have been expected.

Time of the Shock at Different Places.—Time-observations are subject to error from the clock not showing correct time, from incorrect readings, and from observations being taken at different periods of the shock. The first source of error is got over by comparing the clock with telegraph-time as soon as possible after the shock. When a clock is stopped by the earthquake the second source of error is eliminated; but the first and third remain. If, however, the time of the shock is correctly given to the nearest minute, and the stations are sufficiently distant from each other, fairly accurate determinations may be made from them; and experience has shown that in a civilised country, with telegraphs and railways, these time-observations are of great value. The following are the times reported:—

	H.	M.		H.	M.		H.	M.
New Plymouth ..	4	15	Rangiora ..	4	12	Timaru ..	4	11
Manaia ..	4	10	Christchurch ..	4	12	Lyell ..	4	11
Wanganui ..	4	10	Lyttelton ..	4	13	Westport ..	4	10
Feilding ..	4	10	Akaroa ..	4	10	Boatman's ..	4	8
Masterton ..	4	15	Selwyn ..	4	15	Reefton ..	4	10
Wellington ..	4	15	Lauriston ..	4	13	Notown ..	4	11
Nelson ..	4	12	Ashburton ..	4	13·5	Greymouth ..	4	10
Havelock ..	4	15	Leeston ..	4	20	Hokitika ..	4	12
Blenheim ..	4	15	Kirwee ..	4	23	Queenstown ..	4	10?
Kaikoura ..	4	12	Bealey ..	4	10	Dunedin ..	4	15
Hanmer Plains ..	4	12?	Fairlie Creek ..	4	12	Invercargill ..	4	15
Waikari ..	4	13						

A cursory inspection of this list will show that many of

the localities must be rejected as too inaccurate. After careful consideration, and from information obtained, I judge the following eight places to give the most trustworthy records for the purpose of discovering the epicentrum—viz., Christchurch, Ashburton, Lauriston, Kaikoura, Bealey, Boatman's, Westport, and Greymouth.

I first tried to draw coseimal lines; but found the data far too meagre for any useful purpose.

I next attempted to find the position of the epicentrum by the method of straight lines,* using three pairs—viz., Westport and Greymouth, Greymouth and Bealey, Christchurch and Kaikoura. By this means, on the Government map of twenty-five miles to the inch, I found the position of the epicentrum to be in the Upper Grey, six or seven miles west of Lake Christabel, or five to six miles north-west of the Amuri Pass.

I then tried the method of circles, with the following results, all being taken on the twenty-five-miles-to-the-inch map. Greymouth, Ashburton, and Kaikoura gave it in the Upper Grey, near Lake Christabel; Bealey, Boatman's, and Christchurch gave it one mile north of Lake Christabel; Bealey, Christchurch, and Kaikoura gave it between Lake Christabel and the Amuri Pass; Greymouth, Boatman's, and Kaikoura, half-way between Lake Christabel and the Amuri Pass. All these localities lie within a circle the radius of which is five miles, and the centre about four miles N.E. of the Amuri Pass. I subsequently obtained a more recent and accurate map, on a scale of eight miles to the inch, and on trying on this the stations Greymouth, Boatman's, and Kaikoura, I found that it gave the position four miles more to the S.E. than the twenty-five-miles-to-the-inch map: thus putting the position of the epicentrum between three and four miles E. of the Amuri Pass, or fourteen miles W.N.W. of Glynn Wye.

Taking all these different methods into consideration, I conclude that the epicentrum was not of an elongated form, but more or less circular, with a radius of perhaps five miles, and the centre a little east of Amuri Pass and about sixteen miles W.N.W. from Glynn Wye.

Depth of the Centrum.

When we consider that the earthquake-wave spread for a distance of three hundred miles from the epicentrum, it becomes evident that the centrum was deeply seated, and this conviction is strengthened by the fact that the wave passed below high mountain-ranges, to Greymouth and Westport on the one hand and to Kaikoura on the other, without any apparent effect

* For this and the following methods, see Milne's "Earthquakes," International Scientific Series, p. 200.

being produced by them. It was also felt strongly in the mines at Reefton. In order to obtain some idea of its depth I tried Professor Milne's method of co-ordinates, but without success. As each of the simultaneous equations is more or less inaccurate, different results are obtained by combining them in different ways, and I found, after many attempts, that these results for velocity of transit and depth of centrum were so discordant that I lost all confidence in them. The method is a very good one when the data are sufficiently accurate; but it is not adapted for obtaining the most probable result from a mass of incorrect data.

We have seen that the effects of the shock were most severe in the neighbourhood of Glynn Wye, so that probably the angle of emergence was here between 45° and 55°, and this, with the epicentrum situated sixteen miles away, would give the depth of the centrum between sixteen and twenty-three miles. When we have discussed the velocity of propagation we shall be able to make another approximation to the position of the centre of the centrum.

VELOCITY OF PROPAGATION.

Westport, Boatman's, and the epicentrum are nearly in a straight line; and, if d is the distance of the centrum from Westport, and d_1 its distance from Boatman's, t and t_1, being the time taken by the wave to pass to each place respectively, then we have, on the assumption that the velocity is the same in both cases—

$$d^2 = v^2t^2;\ d_1^2 = v^2t_1^2;\ \text{and } t - t_1 = 2 \text{ minutes.}$$

$$\therefore \frac{d^2}{t^2} = \frac{d_1^2}{t_1^2}.$$

$$\left.\begin{array}{ll}(1.) & d_1t - dt_1 = 0. \\ (2.) & t - t_1 = 2.\end{array}\right\}$$

Eliminating t_1 from these two equations, we have—

$$t = \frac{2d}{d - d_1}.$$

$$\text{Also } v = \frac{d}{t}.$$

The values of d and d_1 depend upon the depth at which we place the centrum, and consequently t and v depend upon it also. The following results are obtained for different values of z, which is the depth of the centrum below the surface; the distance of Westport from the epicentrum being sixty-two miles, and Boatman's thirty-six miles:—

If $z = 15$, then $t = 5{\cdot}15$ and $v = 12{\cdot}39$, or 1,090ft. per second.
If $z = 20$, then $t = 5{\cdot}46$ and $v = 11{\cdot}92$, or 1,049ft. per second.
If $z = 25$, then $t = 5{\cdot}81$ and $v = 10{\cdot}74$, or 945ft. per second.

The time the shock took place at the centrum will be between 4h. 4·85m. and 4h. 4·19m., or, say, 4h. 4m. 30s.

But at stations like Ashburton and Christchurch, which are at a considerable distance from the epicentrum, the depth of the centrum will affect the distance very little, and therefore the velocity of propagation calculated from these places will be almost independent of z. Assuming that the time of shock at the centrum was 10h. 4·5m., and that the depth of the centrum was 20 miles, the distance of Christchurch from the centrum will be about 79 miles, and that of Ashburton about 104 miles. The time of shock at Christchurch was 4h. 12m., and at Ashburton 4h. 13·5m.; consequently the velocity of propagation to Christchurch was 10·5 miles per minute, and to Ashburton 11·5 miles per minute, the mean being 11 miles per minute, or 968ft. per second. This indicates the depth of the centrum at 24 miles, and probably about 20 miles is as near an approximation as the nature of the data at our disposal will admit of. The size of the centrum we have no means of estimating.

From this it follows that the wave arrived at the epicentrum at about 4h. 6m., and that the average velocity of propagation *along the surface* was, from the epicentrum to Boatman's, 1,584ft. per second, and from Boatman's to Westport 1,232ft. per second.

In attempting to locate the epicentrum from time-observations it is assumed that the rate of propagation was the same in different directions; and the result of that attempt agrees so closely with the result arrived at by the methods of greatest intensity and of direction of shock that we may conclude that, to the places used for this purpose, the rate of propagation was approximately the same, and that it was about 12·8 miles per minute, or 1,082ft. per second, along the surface.

If, however, we take the distant stations, we find a much faster rate: to Timaru, 28·4 miles per minute; to Dunedin, 27·4; to Invercargill, 36·1; and to New Plymouth, 29·7 miles per minute. As it is impossible to suppose that the earthquake travelled faster at a distance than it did near its origin, it looks at first as if there must be errors in the time. But if we assume that it travelled at the rate of 12 miles per minute all round, it should have arrived at Timaru at 4h. 18m.; at Dunedin at 4h. 26m.; at Invercargill at 4h. 33m.; and at New Plymouth at 4h. 28m. This supposes errors in time of from seven to eighteen minutes, which could not have been the case. The only possible explanation that occurs to me is that the shock was transmitted with great velocity along the mountains in a south-west direction to Queenstown, and that Invercargill and Dunedin received the shock from there. This would agree with the direction of the shock given at Dunedin,

but it would not agree with the time given at Bealey. The postmaster at Queenstown informs me that the shock occurred there at about 4h. 10m., but he cannot guarantee the accuracy of the clock observed: the direction he gives is N.W. to S.E. The same explanation, however, will not apply to New Plymouth, although, on the other hand, we cannot believe that there is an error here of thirteen minutes in the time. I give this problem up.

Judging from the slow rate of propagation, this earthquake ought to be considered as a small one, notwithstanding the great area over which it was felt; but until we have seismographs to register the amplitude of the wave it will not be possible to compare our earthquakes with those of other countries. .

SOUNDS HEARD.

In several places the rumbling sound which often precedes an earthquake was heard—caused, no doubt, by the fracture of rocks, and transmitted as a sound-wave through the earth, the noise which accompanies or follows an earthquake being a sound-wave through the air. In the Otira loud rumbling noises like thunder were heard before the shock; and at Jackson's accommodation-house, on the Teremakau, there was a long-continued roll, as of artillery, during the greater part of the night. This latter, however, like the noise heard at Tekoa station, was probably produced by falling rocks.

In the Amuri District noises like the falling of avalanches or the firing of cannon were very frequent and loud on the Saturday and Sunday following the earthquake of the 1st September. By the end of the week they had become faint, and at distant, irregular intervals only; but they are heard occasionally up to the present time. There can, I think, be no doubt but that these sounds were heard occasionally for many months before the earthquake; but before that date they were never followed by a shock, and consequently must have been small. Mr. Stewart, who has charge of the baths at Hanmer, told me that on the 19th August he heard a number of sharp booms at regular intervals, none of which was accompanied by a shock. He heard no more until after the main shock on the 1st September. Even on that day the noises were not very loud. They were loud enough to be heard in a coach when travelling, but it is a great exaggeration to say that they were so loud that people could not hear each other speak. Earthquakes often occurred without any sounds; but immediately after the severe shock of 11.30 p.m., 28th September, the booming sounds became again very frequent, more than twenty-five loud booms being counted within an hour after the first shock, and these booms continued for two days. Again,

the shock of 2.30 a.m., 12th October, was followed by incessant booming like the fire of artillery in the distance, but some of the explosions seemed quite close at hand. A visitor thus describes them: "On Friday, the 12th October, at 2.25 a.m., I was awakened out of sleep by a most violent shock, or, rather, double shock, as there was a break of some two or three seconds in it. As soon as this had subsided these underground explosions began, and followed each other at intervals of, say, five seconds for some minutes, when they diminished in quantity but increased in strength, until every explosion made the house (a galvanized-iron one) quiver and rattle. This continued until 8 o'clock a.m., during which time we had seventeen shocks, five of which may be termed sharp." I myself heard two booms on the 3rd November and three on the 9th November. Those of the 3rd November were at about twenty seconds' interval, and each lasted about five seconds. The sound was like that of a distant avalanche; they were not loud, and were not followed by any shock. Those on the 9th November were of quite a different character: they were short and sharp, like the explosion of a cannon at a distance. They were not followed by a shock, but I fancied that there was a slight shake simultaneous with the sound and quite as short. This, of course, would be an air-reverberation, and not an earth-wave. One of these booms was at 10.30 a.m., another at 3.14 p.m., and the third at 3.20 p.m. There was also another of a similar nature at about 2 a.m. the next morning. Mr. McKay mentions having heard noises of two different characters—one on the 7th October, which resembled the rumble of a distant avalanche, and was accompanied by a slight shock; the other, which was later on the same day, resembled a strong blasting-shot in a mine, and was not succeeded by a shock. Inquiries made on the ground lead me to think that these two kinds of sounds have been heard all through, and that each kind, when loud, was followed by a slight shock at about two seconds' interval.

On the 13th November there was a loud boom at 2.10 a.m. and another at 10.5 a.m. Both these were followed, at between one and two seconds' interval, by a sharp short shake, like the blow of a hammer, quite distinct in character from the earthquakes unaccompanied by a boom, one of which took place at 11 a.m. on the same day, and has already been mentioned as a swaying movement lasting for thirty seconds.

These sounds have been heard in the valleys of the Hope and the Edwards, and doubtfully at Cannibal Gorge, as well as on Hanmer Plains and the hills immediately surrounding them; but they were not heard at Culverden or Waikari on the south, nor at Tarndale on the north, nor at Reefton or Boatman's or Lyell on the west. At the Hanmer Plains it is

generally agreed that they came from various directions between west and north; and they appear to me to proceed from an elongated area some thirty miles in length, between the hot springs in the Hope and the hot springs in Cow Creek, or perhaps from the neighbourhood of these two localities only.

As a rule the hot springs at Hanmer showed no sympathetic action with the noises, the only exception being a sharp boom, like a cannon-shot, at about 11.15 a.m. on the 14th September, accompanied by a shock which appeared to be nearly vertical. On this occasion a small quantity of mud and water was thrown from one of the smaller springs only.

It is difficult to offer a satisfactory explanation of these noises: they have been heard with other earthquakes, but never explained. In our case it is evident that the main earthquake, and all those of the same character that followed it, were quite independent of the cause of the booms. This is shown by the fact that many shocks were not accompanied by any noises, although they were heavier than those following the booms, and also by the heavier shocks of the 1st September, 28th September, and 12th October being followed, not preceded, by noises for several days. On the other hand, as the booms were heard before the main earthquake, their origin must be independent of it; but, as they were far more frequent and much louder after the shocks, it is evident that to a large extent they were secondary effects of the earthquake.

Mr. Mallet suggests that the noises heard after the Cachar earthquakes of 1869 were due to grinding or crushing of rocks; but this explanation will hardly do for our case, because many of the earthquakes were not accompanied by noises, and the booms do not come from the direction of the epicentrum of the earthquakes. The sounds appear to me to be much more like explosions of steam than crushing of rock; and this seems to be the only other explanation. There is no direct evidence to show that they are connected in any way with the hot springs, but their geographical distribution strongly suggests it. Hot underground water undoubtedly exists in the district in which the sounds have been heard, and at a comparatively small depth this water may be above the boiling-point, but kept fluid by pressure. If this pressure were removed, part or the whole might flash into steam and produce an explosion which would cause a boom. An earthquake might first compress this water, and then, on the backward swing of the wave, the pressure would be relieved and explosions take place; or part of the heated water might be expelled by the shock, which would reduce the pressure on the rest. It seems useless to offer such speculations as these, and I should not have done so if it had not been suggested that these ex-

plosions were caused by "the gradual upheaval of a molten dyke through the upper strata of rocks"—an hypothesis which rests on no evidence whatever.

It appears, therefore, that there have been in the Hanmer Plains two kinds of earthquakes, due to different causes and originating in different places.

Luminous Appearances in the Sky.

At Reefton, in the early morning and in the evening of the 1st September, a "luminous appearance" is reported to have been seen in the eastern sky in the direction of Christchurch, and it was again highly visible on the evening of the 8th September. In Dunedin, on the evening of the 1st September, an extraordinary glow was observed in the western sky, noticeable until after midnight, and it travelled southwards. I mention these things, but I do not think that they were in any way connected with the earthquake.

Unequal Effects of the Earthquake.

It is well known that the effects produced by an earthquake are often apparently capricious. Sir C. Lyell says that in the Calabrian earthquake of 1783 "in some streets of Monteleone every house was thrown down but one, in others all but two; and the buildings which were spared were often scarcely in the least injured." And many other examples could be given. Much of this may be due to the different materials of which houses are built, to their different plans of construction, or to their different foundations; still, when due allowance has been made for all these things, a balance often remains over which can only be explained on the supposition that the shock was actually more severe in some places than in others, irrespective of their distance from the place of origin. More than forty years ago Mr. Robert Mallet proposed a theory to account for these apparent eccentricities. He said, "Where a wave of elastic compression, such as our earth-wave, passes through a body varying in specific elasticity in several parts of its course, or passes from one body to another of different elasticity, at each such change of medium the wave changes its velocity and in part changes its course, a portion being reflected and a portion refracted, analogous to a wave of light in passing through media of variable density or of different refractive indices."* This explanation has been universally received as correct; but it can only be applied to particular cases when the local details of geological structure are well known; and before attempt-

* "Dynamics of Earthquakes," Pro. Royal Irish Academy, 1846, p. 26.

ing to apply it to our earthquake it will be useful to explain the theory rather more fully.

Rock, of all kinds, is a more highly elastic material than alluvial gravel or sand, and when an earth-wave passes from rock into alluvium it will, unless it be perpendicular to the plane of junction of the two formations, be partly reflected downward and partly refracted towards the perpendicular to the plane of junction (Pl. XVII., fig. 1). If, however, the direction of the wave was very oblique to the plane of junction, the whole wave might be reflected down into the earth, and no shock would be felt on the alluvium (Pl. XVII., fig. 2). On the other hand, when the wave passes from alluvium into rock the refracted portion will be bent away from the perpendicular to the plane of junction, and the reflected portion will have its angle of emergence increased (Pl. XVII., fig. 3); but if the angle is small between the direction of the wave and the plane of junction, then total reflection of the wave in an upward direction will take place (Pl. XVII., fig. 4). This upward reflection might be in the same azimuth as the direction of the earth-wave, but more commonly the wave will be diverted to the right or left according to the inclination of the plane of junction. It is only the cases of total reflection that need be considered here.

The slopes of old valleys covered up with alluvium vary very much; but, as the earth-wave is always more or less emergent, the angle formed by the wave with the plane of junction on entering alluvium will generally be greater than the same angle when the wave is leaving alluvium: consequently, total reflection will be rare where the wave enters an alluvial plain, but will be common where the wave leaves it. A glance at Plate XVII. will explain this. It follows, therefore, that along those margins of alluvial plains where the rocky slopes face the origin of the earthquake the shock may be doubled or trebled in force; while along those margins where the rocky slopes are turned away from the origin the shock will either be normal or will be diminished in intensity. This does not apply to a narrow valley, for in that case the whole contents of the valley would be forced to vibrate as one system with its rocky walls, and there would be neither refraction nor reflection. I will now try to apply these principles.

Jack's Pass Hotel (31 miles from the epicentrum), Jollie's Pass Hotel (34 miles), and Culverden Station (34 miles) are in narrow valleys, and would receive the normal shock only.

Balmoral (30 miles) and Montrose (32 miles) are on alluvial plains near the margin where the wave entered alluvium from rock, and consequently the shock in these places was probably normal also.

Ferry Hotel, Waiau-ua (29 miles distant from epicentrum), is built on rock which is cut off from the earthquake-origin by an alluvial valley; it would therefore, in all probability, receive less than the normal shock due to its distance, because some of the waves may have been totally reflected upwards before reaching it. This hotel is an old cob structure, and manifestly it has not undergone such a severe shaking as Woodbank or St. Helen's were subjected to.

Leslie Hills (33½ miles distant from epicentrum) undoubtedly received a more severe shock than did Montrose or Balmoral, and it is situated on the margin of an alluvial plain, where the wave passed onwards into rock, and consequently in a position where we might expect an increase in the violence of the shock from total reflection upwards. The same explanation applies to Highfield (46 miles distant), where several chimneys were thrown down; for it stands on an alluvial terrace, with hills behind which face westerly.

St. Helen's certainly received a more severe shock than its distance from the epicentrum (32 miles) would warrant, although it stands nearly in the middle of the eastern half of the Hanmer Plains. But the evidence shows that the wave emerged here at a high angle. Hams and bacon were thrown off hooks; a birdcage was also thrown off a hook, and ice was thrown up out of a pool. Evidently the angle of emergence was greater than usual, and I should account for this, as well as for the increased intensity of the shock, by the supposition that the spur between the Hanmer and the Percival Rivers runs down under the alluvial plain below St. Helen's and acted as an earthquake-reflector upwards. It has been supposed that the ground on which St. Helen's is built is swampy, and that that would account for the damage done to the house; but it would not account for the increase in the angle of emergence, and, after seeing the locality, I feel inclined to reject the swamp theory altogether.

At Woodbank (28 miles distant) the shock was undoubtedly more severe than its mere distance from the epicentrum would explain. I do not take into consideration the brick portion of the building, which was old and put up with bad mortar, but the wooden part of the house, which was shifted bodily 2½in. Here, also, cob huts, not worse built than the Ferry Hotel, were rendered quite uninhabitable, while the Ferry Hotel, only one mile further from the epicentrum than Woodbank, was scarcely injured. At Woodbank, also, a cement chimney-top was thrown up and then fell over on to the roof of the wooden part of the house, which indicates not only a very strong shock, but also a high angle of emergence. This is confirmed by Mr. Atkinson, who says that when standing outside his house immediately after the first shock

he felt a series of strong upward shakes in the ground. I think therefore that at Woodbank the shock must have been locally increased by reflection from below; but it is not easy to say why this should have taken place. The house stands at the northern margin of the alluvial plain, but a spur of the hills comes down between the house and the origin of the earthquake so far that the end of the spur bears south-west from the house. This spur ought to have prevented total reflection upwards from taking place. The only suppositions that occur to me are that either the shocks here came from more to the south—that is, from the valley of the Waiau-ua—or else that an underground spur exists from the hills east of Woodbank, which would act as a reflector of the earth-wave. Neither of these suppositions appears to me to be probable.

At the Hanmer Hot Springs the intensity of the shock was probably that due to the distance (31¼ miles) from the epicentrum, neither augmented nor diminished.

CAUSE OF THE EARTHQUAKE.

All ordinary earthquakes are due to one of two causes—they are the result either of subterranean explosions of steam or of the crushing or fracturing of rocks. There may occasionally be an earthquake due to some other and exceptional cause, but these must be rare.

The first cause—explosion of steam—is due to water coming into contact with heated rock; and, as the water must originally have been surface-water—*i.e.*, rain-water—the heated rocks must be near the surface of the earth, and the centrum of the earthquake must also be more or less superficial. These earthquakes are usually found associated with volcanoes or in hot-spring districts, and always occur previous to and during the progress of an eruption; although they also often take place without an eruption. The earthquakes felt in the hot-spring district from Lake Taupo to Rotorua are no doubt of this origin.

The second cause—fracture of rocks—is due to the gradual increase of strain on the rocks until at last they give way with a more or less sudden snap and jar. These strains may be due to lateral pressure in the earth's crust, which crumples it up and forms mountain-chains; or they may be due to the gradual relief from pressure owing to the denudation of the surface, which is more rapid in mountain-ranges than elsewhere; or they may be due to the gradual increase of pressure brought about by the deposition of mud or sand on the sea-bottom, a cause which acts most rapidly near the mouths of great rivers. Earthquakes due to this cause may occur in almost any part of the world, but they are most numerous in mountain-ranges and near the mouths of large rivers. Many

of them are small and local, but others are far more violent than earthquakes due to explosions of steam, and, as the centrum is often deeply seated, they are often felt over a very wide area.

The earthquake of Wellington in 1855 was one of this kind, as also are, no doubt, most or all of those in the South Island. The Wellington earthquake, however, belongs to a very rare class, in which the centrum extends to the surface, and surface-rocks are moved. In a large majority of cases no movement takes place in the surface-rocks* except that due to the earth-wave generated below by the fractures.

Small earthquakes may not be accompanied by actual fracture of rocks; and when there is no fracture no noise will be heard, although the shock may be felt for a considerable distance: for the waves of sound in the earth are produced by the fractures.

In the earthquake we are now considering the shake was of an unusual character, inasmuch as it was long and even, without any violent jerks; but, as it was accompanied by a sound-wave, fractures of some kind must have taken place. These fractures could not have been due to an explosion or to a very sudden break or split: they appear to me to have been due to a slow splitting or crushing of rocks.

At first sight the evidence seems to favour the idea of a slow splitting having taken place along an east-and-west line in the valleys of the Waiau-ua and Hanmer, for it was in this direction that most of the damage was done. But this idea is much weakened when we remember that this is the only line which is even fairly well inhabited, and is the only line along which an alluvial valley approaches the epicentrum; and when we examine the evidence attentively I think we must give up the idea altogether. It is certainly in favour of it that a better explanation could then be given of the destruction caused at Woodbank; but this is the only favourable fact that I can find, for no fault or fissure has been proved from other evidence to exist in the valleys of the Waiau-ua and Hanmer, and no fracture or movement of solid rock has been found anywhere in the neighbourhood. On the other hand this line has a distinct meizoseimal band, and if it were a line of fissure reaching to the surface the shock would have commenced at this band and gone both ways, which is distinctly contradicted by both an eye-witness and by time-observations. Again, the Ferry Hotel stands on the very edge of this supposed fissure, and ought to have suffered more than Leslie Hills or Highfield. And, again, no explanation is in this way given of the strength of the shock at Tekoa and in the Otira,

* By the term "surface-rocks" I do not include alluvium, &c.

which is from forty to fifty miles south-west of the position of the epicentrum.

Certainly, Professor De Rossi has stated that in the neighbourhood of Rome the rock-fissures form axes of propagation of the earth-wave, the movement being at first parallel with and then at right angles to the axis of the fissure; but the even outward spread of our earthquake shows no such connection, and we do not yet know the geology of the district sufficiently well to say where the fissures are. In our case time-observations point to the conclusion that the locus of the centrum was small and without any well-marked seismic radiant like those so often found in other earthquakes, and I should therefore conclude that our earthquake was not due to splitting, or movement along a fissure, but to the crushing of a compact mass of rock.

Art. XXXIII.—*On the Fossil Marine Diatomaceous Deposit near Oamaru.*

By Harry A. de Lautour, M.R.C.S.E.

[*Read before the Otago Institute 12th June, 1888.*]

Plates XVIII–XXIII.

Considerable interest has been excited in scientific circles throughout the world by the reports of Messrs. E. Grove and G. Sturt on the deposit of diatomaceous earth found at Cormack's siding, near Oamaru, which were published in the "Journal of the Quekett Microscopical Club."*

The attention of these gentlemen was drawn by Mr. H. Morland to a specimen sent home to the Colonial Exhibition in 1886, and further specimens were given them by the late Sir Julius von Haast.

It is not quite clear who sent the original specimen to the Colonial Exhibition, neither does it matter very much. Certainly, early in 1886 the late Resident Magistrate here, Mr. H. W. Robinson (now Resident Magistrate at Wellington), received a circular letter from Dr. Hector (now Sir James Hector) asking for specimens of various kinds from this district. Mr. Robinson consulted me on the matter, and I suggested that amongst other things he should send some peculiar earth, which I then thought was a form of kaolin, from Cormack's siding, Cave Valley. My attention had been drawn to this deposit by Mr. A. McKay, of the Geological Depart-

* "Journ. Quekett Micr. Club," 16th September, 1886; 17th January, 1887; 18th May, 1887; and 19th August, 1887.

ment in Wellington, in 1882, and since that time I have used it for various purposes. Under the microscope I found diatoms in it, but was then very ignorant of the whole subject, and was unaware that any new forms existed in it; but from remarks passed by Mr. McKay I gathered that the earth, or ooze, had more than passing interest, and thus I was induced to give some of it to Mr. Robinson for the Exhibition. Shortly after Mr. Robinson informed me that he had received a report on the earth from the Geological Department that it was not kaolin, but "diatomaceous earth."

Messrs. Grove and Sturt are amongst the foremost of the authorities on *Diatomaceæ* in Great Britain. The former some years ago investigated and described some of our New Zealand freshwater *Diatomaceæ* sent to him by the late Mr. Inglis, of Christchurch.* These gentlemen at once recognised the richness of this deposit, and ascertained the presence of a number of forms new to science. In their papers and reports referred to above they give a description and list of 283 forms, of which 107 are new species or varieties. They also have discovered four new genera—*Anthodiscus*, *Kittonia*, *Monopsia*, and *Huttonia*, the latter named after Captain Hutton—and a new sub-genus, *Pseudo-rutilaria*. Since then other samples of diatomaceous ooze from other localities—which, as I will presently show, vary considerably from that at Cormack's siding—have been sent to these gentlemen; and I have no doubt but that the list of species will be much extended.

In their first communication Messrs. Grove and Sturt note that the deposit consists "mainly of diatomaceous remains, with a small proportion of *Radiolaria* and sponge-spicules:" and they call attention to the interesting and curious fact that several of the forms existing here have previously only been found in the Cambridge Estate, Barbadoes; that others, again, resembled forms found previously only in Simbirsk, in Russia, and also at Brünn, in the fossil condition; and they remark that several of the forms are still to be found living in the Indian Ocean.

Since I commenced this paper I have received from Mr. Grove a very valuable and representative collection of *Diatomaceæ* from various parts of the world, in which he has taken the trouble to select and mark diatoms found in Japan, Hongkong, Fiji, and Bombay, in the living conditions, exactly similar to those found here in Oamaru as fossils. A slide from the Barbadoes deposit is very similar to one prepared from our deposit; and I have found similar diatoms in ooze gathered in the "Challenger" expedition given me by

* "Trans. N.Z. Inst.," vol. xv., p. 340.

Dr. Colquhoun, and also in some diatoms found in guano given me by Dr. de Zouche.

This discovery led to much inquiry, and many were the requests sent to various persons in Oamaru from all parts for specimens of the earth; and I am sorry to say that a great deal of the wrong material has been sent away—perfectly useless. One parcel alone of nearly 200lb. weight contained only one or two lumps of earth containing diatoms, and those were by no means rich.

To obviate this, and avoid disappointment for the future, I have prepared a map of the district (Pl. XVIII.) showing the deposits as far as they have been hitherto found, and the roads leading to them. The deposits are so extensive that there is no fear of their becoming exhausted. One alone at Jackson's is about a quarter of a mile long, and shows a face of some 60ft. How far it goes back I have no means of ascertaining. I have also prepared diagrammatic sketches showing the appearance of the deposits as exposed, and the relation of the diatomaceous ooze to the other earths.

Plate XIX., fig. 1, shows a section of the railway-cutting at Cormack's siding. Here the prominent feature is the volcanic dyke, *b*, cutting through it; on each side is a hard white earth very similar to the proper diatom ooze in appearance, but heavier and much harder. This is the earth which has been sent home, and which has led to so much vexation. It is more easily collected. Between the volcanic dyke and this hard material there is a distinct line of demarcation, but none exists between the hard material and the true diatom earth; and as a matter of fact the further away from the dyke the richer is the ooze in diatoms and other siliceous remains. Hence I would infer that the intruding dyke has heated and partly fused and compressed the diatom earth through which it has burst. The same condition is found in various other places where dykes exist or where there appears to be a flow of lava, as under Jackson's paddock (Plate XIX., fig. 2*b*): there, along the road-line, is a volcanic layer similar in its appearance to the dyke at Cormack's, and with the same hard white stuff. At many points in Cave Valley, and in the Waiärekei Valley below Jackson's, Bain's, and Totara, does the same condition exist; and also, in the neighbourhood of these places the plough turns up pure diatom ooze. The diatom ooze, also, at Cormack's, as in the other sub-volcanic deposits, is non-calcareous. Microscopically it is peculiar in the number of a species of diatom called *Stephanopyxis* present in it, and which may be said to be characteristic of it. Also, this non-calcareous ooze has a much smaller quantity of *Radiolaria*—*i.e.*, *Polycystinæ*, &c.—and sponge-spicules in it than the calcareous diatom ooze which is found above the volcanic remains. I have

endeavoured to show this in Plate XX., fig. 1, representative of Cormack's siding; fig. 2, of H. Allen's. (The sub-volcanic deposit at Bain's is very similar to these.) In these it will be noticed that the diatoms, *Polycystinæ*, and sponge-spicules are much smaller than in figs. 4 and 5, which represent the forms found in the supra-volcanic calcareous diatom earth in Jackson's and Bain's; also that in the former or sub-volcanic deposits *Stephanopyxis* abounds, and is absent, or, at any rate, rare, in the latter. Fig. 3 shows a peculiar deposit on the Totara Estate. It is a continuation of the upper layer of Bain's sub-volcanic layers, and lies somewhat higher. I am unable to account for the minute character of the diatomaceous remains found here unless it be a question of gravity, and that the diatom mud was shaken up and the heavier forms fell to the lower depths.

Although the large forms are much more abundant in Jackson's and Bain's, and much more perfect, it must not be assumed that they are absent in the other deposits, for they are found, but only in fragments and scarce. Mr. Grove accounts for their better preservation in Jackson's by the larger forms of the sponge-remains and the great quantity of the spongioliths: the diatom-valves falling amongst them would be protected.

I suggested previously that the hard white material was altered and semi-fused diatom earth—altered by the action of the intense heat of the volcanic lava in the dyke. This theory seems confirmed by the conditions of the layers at Bain's and at Allen's. Here the volcanic remains consist of tuff, or volcanic ash, and this seems to me to have settled down on the diatomaceous ooze in a cooled state, for I find that the white earth immediately attached to the tuff is just as rich in diatoms as any other part of the deposit; and, indeed, some of the tuff is perforated by or surrounds hollows filled up by pure diatom ooze.

I have not yet referred to the Ototara limestone lying above the diatom earth and the volcanic remains, and feel very diffident in putting forth any theory on the geological conditions and ages of the deposits, but I will do so in order to invite discussion and obtain information from those well calculated to give it.

It seems to me that at a very early period of the history of this part of the world matters were very quiet, and that there was a greater excess of vegetable life, and that animal life was then less abundant. This period of rest was disturbed by volcanic irruptions, and possibly the levels were altered. After this disturbed era had passed away a fresh growth of vegetable and animal life followed, but, owing to some change of conditions, the animal life, as represented by the *Polycystinæ* and sponges,

became more abundant and prolific; then, in order to fulfil their functions in the balance of nature, the *Diatomaceæ* also increased in number and size; and, finally, that, the conditions being prepared for them, the higher forms of animal life appeared and formed the limestone.

Dr. G. Hartwig in "The Sea and its Living Wonders" says, "Without the diatoms there would be neither food for aquatic animals nor (if it were possible for these to maintain themselves by preying on one another) could the ocean waters be purified of the carbonic acid which animal respiration would be continually imparting to it. Thus it is not in vain that they abound in the most inhospitable seas, where but for them no sea-bird would flap its wings, and no dolphin dart through the desert waters."

Dr. Hartwig also states that they increase so quickly and multiply by division (other authors say also by conjugation) that in forty-eight hours a single diatom may multiply to 8,000,000, and in four days to 140,000,000,000,000, "when the siliceous coverings of its enormous progeny will already suffice to fill up a space of two cubic feet." (!)

Many other remains found in these earths are highly interesting, and no doubt are new to science. The *Foraminifera* are very abundant, especially in the calcareous deposits. I have figured a few, Plate XX., fig. 6. The *Radiolaria* and *Polycystinæ* are very striking and beautiful forms. As for the spongioliths, they are so abundant and fine in Jackson's deposit that Mr. B. W. Priest, an authority on the sponges, states that for "size, variety, and quantity this deposit far surpasses any previously discovered." Dr. Hind, I may add, is preparing a monograph on the spongioliths of this locality.

In examining the various deposits, and in working out various details in connection with this paper, I have received much assistance from Messrs. John Forrester and C. Peach, of the Oamaru Harbour Board. Mr. Charles Gifford, of the Waitaki High School, was, I believe, the first to find out and examine the deposit in Jackson's paddock. Mr. Th. Isdaile, of Enfield, has also given me much valuable information.

With regard to the practical uses to which diatomaceous earth may be applied, much, I imagine, depends upon its purity and the relative quantity of silica which it contains. I regret that I have been unable to get an analysis of this deposit, and therefore cannot give the requisite information. The uses, however, to which diatom earth has been put are many and important, and doubtless many others will be discovered in the future. These, however, have been enumerated by Mr. H. G. Hanks, State Mineralogist, California:—

(1.) As a polishing-powder diatom earth has long been used in the form of tripoli. As has been remarked, these almost

invisible organisms give invisible scratches; hence the value of the earth as a polishing-powder.

(2.) In the manufacture of silicate of potash or silicate of soda—"*wasser glasse*" or liquid glass. This is becoming a most useful article, and may be prepared by treating diatom earth with hydrate of lime and then with potash or soda. Liquid glass is useful for many things, such as making a fire-proof paint for wood, in the manufacture of soap; and is far better than plaster of Paris or gum and starch for use in stiff bandages for surgical purposes.

(3.) In the manufacture of porcelain.

(4.) For making cement.

(5.) As a filtering medium.

(6.) For lighting fires. Taking advantage of its highly absorbent properties, it is fitted in convenient sizes to an iron-wire handle, then saturated with kerosene. When it is desired to light a fire put a match to the saturated earth and place it between the bars of the grate. When the fire is lit remove the earth and blow it out, and use again when required.

(7.) A lost art—one known to the ancients—has been rediscovered—viz., the art of making floating bricks. This is done by the addition of one-twentieth of clay.

(8.) In the manufacture of dynamite and lithofracteur, the first containing 73 per cent. of nitro-glycerine, the latter 69 per cent.

(9.) As a surgical dressing for suppurating wounds. I have long used it for this purpose. It is highly absorbent and unirritating. I find that 60 grains of diatom earth, quite dry, will absorb in a couple of hours more than its own weight of water. One piece that I tried weighed 60 grains dry, and 135 grains when saturated. I powder it finely and add small quantities of some antiseptic, and dust it over the wound.

Now as to the methods to be adopted to clean and mount the diatoms in this deposit. The first thing to be done is to disintegrate the earth. This can be done (a very slow process) by soaking the earth a very long time in water and letting it crumble, and then carefully washing out the clay. A much quicker plan has been suggested by M. Parmentier, a professor of chemistry in Belgium, and was communicated by M. Guimard to the Quekett Club.*

It consists in the supersaturation of the earth by some neutral salt, and then recrystallizing it. The crystals penetrate in every direction; then, when redissolved, the earth breaks up into a fine powder. More exactly, place a few small fragments of the earth, the size of peas, in a test-tube, and cover them to about 2 centimetres with acetate of soda, and add a

* "Journ. Quekett Club," Dec., 1887.

drop or two of water. The exact proportion is 5 c. centimetres of water to 100 c.c. of the salt. Heat in a water-bath. Just before reaching the boiling-point the salt will melt and be absorbed by the earth. Allow it to remain about ten minutes in the bath—a little longer will not do it any harm (I find that taking it out of the bath and giving it a good boil assists materially)—then allow it to cool. When quite cool add a fragment of the crystal acetate of soda, when the whole will immediately crystallize. Let it do so thoroughly. Then add water in excess. Heat and empty into a large and suitable vessel, and add quantities of water to wash out the acetate. I find boiling water is the best, and that the process is much facilitated by the addition of a small quantity of hydrochloric acid. If necessary the process may be repeated. It may be as well to observe that in this, as in all the other washings, the great thing is plenty of water and plenty of patience. Working at it for an hour or two a day, you will be fortunate if you have got your diatoms thoroughly clean in a week.

Many works relate various methods of cleaning diatom earth, but the methods are somewhat intricate and the directions somewhat vague. It was not until Mr. Joseph Stevens, of 18, Conference Street, Christchurch, came on a visit to Oamaru and showed us his method that we were able to work satisfactorily. And I may say I have never seen better specimens of mounting than those given me by Mr. Stevens.

Mr. Stevens's method is first boiling the disintegrated earth with strong sulphuric acid—the strongest possible. After boiling a few minutes add cautiously small quantities of chlorate of potash while boiling. The quantity of H_2SO_4 used is about twice the quantity of earth to be acted on, which must contain as little moisture as is conveniently possible. The boiling is continued until the earth becomes either brown or pitch-black, which depends on the quantity of organic matter in it, and the consequent charring or carbonising of the organic dirt. The chlorate of potash is added while boiling, to bleach the earth. (Some authors recommend permanganate of potash as being safer.) The oxygen unites with the carbon, and in a short time the blackened earth is as white as snow. This process, which is conducted in a large test-tube, is the first step, and you will succeed better by not attempting to work with too much earth at a time—a teaspoonful, or even less, is quite enough. And I would caution you to be very careful when first bringing the sulphuric acid to a boil. Do not be in a hurry—bring it by gentle degrees to a boiling-point; for sometimes it is jumpy, and will suddenly explode out of the test-tube, to the ruin of your table, clothes, and hands. This can be entirely obviated by patience. Remember also that the

boiling-point of sulphuric acid is very high, so do not put your test-tube down in a cold place. The next step is to plunge the contents of your test-tube into a flask containing pure cold water. I use a Florence flask for this purpose, containing nearly a pint of water. Pour the boiling sulphuric acid and diatoms (safer to let it cool) into this flask. Do it carefully. It will make a noise, but will do no harm. Let your diatoms settle to the bottom, which they will do in a variable time according to their cleanliness and size (twenty minutes to two hours). You must wash them at least four times to get out the acid. The next step is boiling in an alkali. Here we must be careful and not employ too strong an alkali, neither must we boil it too long, or else your diatoms will disappear. It is true that Mr. Morland recommends boiling alternately in H_2SO_4 and strong liq. potassæ to get rid of refractory dirt in certain instances; but this is unnecessary here. The cheapest material to use is that recommended by Mr. Stevens, and that is "Hudson's extract of soap"—"washing-powder," as used by our housewives for their clothes. We now proceed, using the Florence flask. Having washed out the acid, add a little hot water to the diatoms, and also about 10 or 20 grains of soap-extract—about as much as will cover half an inch of the large blade of your pocket-knife—and boil this—boil it till it boils freely, and stop. Let the diatoms settle. As it cools shake it occasionally to disentangle any diatoms that may be entangled in the scum, and fill the Florence flask up with pure hot water. Some of the *débris*, &c., removed by the soap-powder will rise to the top and some will be held in suspension by the water, the diatoms remaining at the bottom. You will now require three or four washings in pure water to get rid of your alkali, and you may now take a little up with a pipette and examine it under the microscope. You must not be disappointed if you find it still full of dirt, and sand, and *débris*. You may find one or two clean enough to pick off and mount, but there will not be many.

This is the whole process of cleaning so far as chemicals are concerned, and it must be repeated until under the microscope you see the diatoms are free from the minute grains of sand which spoil them. You will have to go through this process perhaps a dozen times before they are quite clean, but, having cleaned them, you will be well rewarded for your trouble.

One great difficulty is to get rid of the sand. Mr. Stevens's plan is to place the cleaned diatoms in a large circular flat-bottomed glass dish—a butter-dish or finger dessert-glass; then shake them up and rotate them as the digger does to separate his gold-dust. When rotating you will see the sand and large spicules collect in the centre at the bottom of the glass, while

your diatoms are floating in the water and flying round and round; then with an ordinary glass syringe suck up the diatoms and squirt them into another glass ready for them, when they will fall to the bottom, and may be collected again clean and free from all coarse sand.

Mr. C. Peach, of Oamaru, has devised a better and more simple plan—one which has the advantage of not running the risk of breaking the valves. Mr. Peach's plan consists in getting a triangular glass dish, which he makes by procuring a triangular piece of glass 4in. to 6in. long and 2in. to 3in. or more broad at the base and ½in. at the apex. He cements to the sides and base narrow strips of glass, about ½in. broad, leaving the mouth open. He holds this dish so that the base is lowest, and puts in a small quantity of the cleaned diatoms and sand, then shakes it gently and taps the trough gently underneath and harder at the base. The sand goes to the lowest part, and the diatoms rise and separate, flowing towards the mouth in the direction given them by the tapping. When well separated it is a very simple matter to pour them into a clean test-tube, and then, when settled down, take up and mount either as a general slide or as a selection.

Here you must remember, unless you have got rid of all the acid and all the alkali you will have trouble: firstly, the diatoms will stick to the glass so that you cannot pick them off; secondly, they will not take kindly to your mounting-medium, and you will be vexed to find them full of air-bubbles.

However, we have now got our clean diatoms. Collect some of the clean sediment in a pipette, and let a drop fall on a perfectly clean slide. Unless the glass is clean the water will not run freely in all directions, and the diatoms will not be equally distributed. You may even find that with all your trouble there is still some sand left. Well, do not mind: this is easily got rid of. Just hold the slide nearly level in your left hand, and tap, tap with the middle-finger nail of the right hand, and you will soon see all the sand collect in a mass at one edge, while the diatoms are distributed evenly all over the slide. This is one of Mr. Stevens's choicest plans, and he deserves credit for its simplicity.

Now to pick them off. You can do this slowly while it is wet by chasing any specially large diatom to the edge with a bristle, then bringing it out of the water, letting it dry, and then picking it up; but I do not recommend this plan. It may be useful for beginners, but it is a waste of time.

The proper method is to proceed as follows: The diatoms being evenly distributed and the sand at one edge, heat the slide gently over a spirit-lamp to drive off the moisture and dry the diatoms. Put on one side to cool. Then, if you have not already prepared some slides, do so in the following man-

ner: On the reverse side of the slide you are going to use describe a circle of ink, either with or without the turntable, in the centre of the glass. This ink-circle is to serve as a guide for you to place your diatoms. Dry it. Then, on the proper surface of the slide put a drop of very weak gum-water so as to cover the space occupied by the ink-circle on the other side. This gum-water must be very weak, and should be filtered; and must be fresh, or else it gets full of fungus.

I adopt a solution of arabin instead, to avoid the nuisance of having to freshly prepare the gum-water each time. The method of preparing arabin is given in the "Microtomists' Vade-mecum" (A. B. Lee). Arabin is the pure gum-extract of gum acacia or arabica, and is prepared by pouring a small quantity of thick gum-and-water into a large quantity of alcohol or spirits of wine. The arabin is insoluble in spirit, and separates as a thick, white, flocculent, opaque mass. It curdles the more as you add more spirit to it. It is then collected by filtering and drying; it is then washed in absolute alcohol and dried again: the result is a fine, pure white powder, freely soluble in water. I prepare it by adding a solution of corrosive sublimate to it, and make a strong solution, from which to make from time to time thinner solutions for use. Practice will quickly teach the proper strength. Well, having put a thin coat of arabin on the slide and dried it, we proceed to pick off our diatoms.

The best thing that I have found for this purpose is a cat's whisker fastened on a thin handle so as to leave about ¼in. of whisker projecting. It is useful to have two or three of these, mounted with various thicknesses, for some diatoms come off easier with one than with the other.

Use a low power to examine your diatoms, and when you find one you want get it in the centre of the field and pick it up. With a little practice you will soon find that the diatom adheres very readily to the bristle or whisker. Now steadily transfer it to the centre of the dried gum. In the same way take off a few others. Now, if you wish you can arrange them in order in rows, or any design you please. Take the slide and breathe on it. This melts the gum or arabin, which runs into the diatoms. While the gum is wet you can push the diatom into any position you like, but it dries very rapidly, and then the least touch will break the diatom. If not satisfied breathe heavily again on the slide. By degrees you will arrange them as you please.

I have recommended mounting on the slide, but this is for beginners: it is much easier. Mounting on the cover-glass gives the best results, and should be the plan adopted.

However, next comes the mounting-medium. Diatoms may be mounted dry, or in some fluid medium such as Canada

balsam. If mounted dry they must be mounted on the cover and placed in a cell. Mr. Morland contributed an excellent paper on mounting-media for diatoms to the "Journal of the Quekett Club," August, 1887. And he remarks that diatoms mounted dry cannot be examined under immersion lenses. Another medium—a *saturated solution of biniodide of mercury and iodide of potassium*—owing to its high refractive index, 1·68, the highest known in any aqueous solution, gives beautiful results, but it is very questionable whether it will last. "The refractive index of this medium is represented by the number 25, as compared with 11 in Canada balsam. In other words, the image is nearly two and a half times as strong."*

Mr. Morland, however, recommends Canada balsam as the best all-round medium. He also recommends styrax. I find this medium is generally coming into use amongst diatomists. It certainly shows up the finer diatoms and the fine markings much better than balsam. It is prepared by getting the ordinary styrax from the chemist, which, by the way, is not true styrax. True styrax has disappeared from commerce, and is replaced by "Liquidambar orientalis," belonging to the order of the "Altingaceæ," or else by "Liquidambar styraciflua," from America. It is very dirty, and for use is prepared by dissolving it in pure benzole or chloroform, filtering, and then drying on a plate in a cool oven to the consistency of shellac, redissolving in benzole or chloroform, filtering twice, and then evaporating to the proper consistency. To avoid disappointment it is as well to remember that the chloroform or benzole must be pure. You will be vexed with the results given by ordinary benzole. "Jackson's" benzole is reliable and the only one to be depended on. It is, however, expensive and scarce.

A mixture of styrax and balsam has been recommended, but I have not tried it. Mr. Morland utterly condemns gum dammar. Other media have been recommended, but in the meantime I would advise Canada balsam or styrax, or a mixture of the two.

To mount the slide, warm it gently, and warm also the cover-glass: put a drop of balsam or styrax, enough for the purpose, over the diatoms, and apply the cover-glass: heat it gently, and examine to see if your specimens are free from air-bubbles; if not, heat to a greater degree, and while warm tap the slide as for the removal of sand, and you will see the air-bubbles come to the edge.

Specimens mounted in Canada balsam do not require a ring of cement, but specimens mounted in styrax must always

* "Microtomists' Vade-mecum."

be ringed. Any of the various cements described will do. I have, myself, used Judson's gold-paint or Kitton's cement, the formula for which is equal parts of red-lead, white-lead, and litharge ground together to a fine powder, and mixed when required for use with a little gold-size.

DESCRIPTION OF PLATES XVIII–XXIII.

Plate XVIII.—Map of Oamaru and district, showing the diatom outcrops or faces at Cormack's siding, Jackson's, Bain's, and Allen's farms. The dotted lines show the area of diatomaceous deposit as mapped out by Mr. Isdaile. Diatom earth has also been ploughed up in Cave Valley and on the east side of the Waiareka Creek. None has, however, yet been found on the west side of the creek, nor on the hills near Totara Round Hill. A small deposit occurs just where the road crosses the railway-bridge to Enfield, but it is of no importance, and is much mixed up with the calcareous *débris* of the disintegrated limestone.

Plate XIX. has been described in the letterpress. (See p. 295.)

Plate XX.—All these figures represent the diatoms of the different deposits, with their characteristic appearance, as shown under a power of about 75 diameters. To have been quite accurate, those in Jackson's and Bain's should have been shown rather larger.

Fig. 1. Deposit from Cormack's siding.
„ 2. „ H. Allen's farm.
„ 3. „ Totara estate.
„ 4. „ Jackson's farm.
„ 5. „ Bain's highest deposit.
„ 6. *Foraminifera* from Jackson's and Bain's farms.

Plate XXI.—

Fig. 1. *Triceratium venulosum*, var. *major*, Gr. and St., n. sp.
„ 2. „ *coscinoides*, Gr. and St., n. sp.
„ 3. „ *rugosum*, Gr. and St., n. sp.
„ 4. „ *dobreeanum*, var. *nova-zealandica*, Gr. and St., n. sp.
„ 5. *Trinacria simulacrum*, Gr. and St., n. sp.
„ 6. *Triceratium morlandii*, Gr. and St., n. sp.
„ 7. „ *oamaruense*, Gr. and St., n. sp.

Plate XXII.—

Fig. 8. *Triceratium crenulatum*, forma *gibbosa* (?), Gr. and St., n. sp.
„ 9. „ „ Gr. and St., n. sp.
„ 10. *Rutilaria radiata*, Gr. and St., n. sp.
„ 11. *Actinoptychus vulgaris*, Schum., var. *maculata*, Gr. and St., n. sp.
„ 12. *Auliscus oamaruensis*, Gr. and St., n. sp.
„ 13. *Aulacodiscus janischii*, Gr. and St., n. sp.
„ 14. *Eunotogramma weissei*, Ehr., var. *producta*, Gr. and St. (Valve.)
„ 15. *Eunotogramma weissei*, Ehr., var. *producta*, Gr. and St. (Frustule.)

Plate XXIII.—

Fig. 16. *Trinacria ventricosa*, Gr. and St., n. sp. (Primary valve.)
„ 17. „ „ „ „ (Secondary valve.)
„ 18. *Pseudo-rutilaria monile*, Gr. and St., n. sp., n. gen.
„ 19. *Hemiaulus ornithocephalus* (?), Grev., var. (?). (Frustule.)
[In this figure half of the adjoining valve is drawn, showing its beak-like claw or spine, by which the opposite valves are attached.]
„ 20. *Kittonia elaborata*, Gr. and St., n. sp., n. gen.
„ 21. *Navicula margino-punctata*, Gr. and St., n. sp.
„ 22. *Triceratium barbadense* (?), Grev.
„ 23. *Aulacodiscus sollitianus*, Norm., var. *nova-zealandica*, Gr. and St., n. var.

List of Diatoms found by Messrs. Grove and Sturt in the Diatomaceous Ooze from Cormack's Siding, Oamaru, and published in the "Quekett Journal" (alphabetically arranged).

Actinoptychus nitidus, Grun. (*Heliopelta nitida*, Grev.).
A. pulchellus, Grun., var. *tenera*.
A. simbirskianus, A. Schm.
A. splendens (Shadbolt), Ralfs.
A. (*splendens*, var.?) *glabratus*, Grun.
A. (*glabratus*, var.?) *elegantulus*, n. sp., Gr. and St.
A. undulatus, Ehr.
A. (*undulatus*, Ehr., var.?) *constrictus*, n. sp., Gr. and St.
A. vulgaris, Schum., var. *maculata*, n. var., Gr. and St.
A. wittianus, Janisch.
Amphiprora rugosa, Pet.
A. (?) *cornuta*, Chase.
Amphora cingulata, Cleve.
Amp. contracta, Grun. (var.?)
Amp. crassa, Greg.
Amp. furcata, Leud. Fort.
Amp. interlineata, n. sp., Gr. and St.
Amp. labuensis, Cleve.
Amp. obtusa, Greg.
Amp. (sp.?)
Amp. subpunctata, n. sp., Gr. and St.
Amp. tesselata, n. sp., Gr. and St.
Anaulus birostratus, Grun.
An. (?) *subconstrictus*, Gr. and St., n. sp.
Anthodiscus floreatus, n. sp., nov. genus, Gr. and St.
Arachnoidiscus ehrenbergii, Bail.
Arach. indicus, E.
Asterolampra decora, Grev.
Ast. marylandica, Ehr.
Ast. uraster, n. sp., Gr. and St.

Aulacodiscus amœnus, Grev., var. *sparso-radiata*, n. var., Gr. and St.
Aulac. angulatus, Grev.
Aulac. barbadensis, Ralfs, "Pritch."
Aulac. cellulosus, n. sp., Gr. and St.
Aulac. cellulosus, Gr. and St., var. *plana*.
Aulac. comterii, Arnott, var. *oamaruensis*, Gr. and St.
Aulac. convexus, n. sp., Gr. and St.
Aulac. crux, Ehr.
Aulac. elegans, n. sp., Gr. and St.
Aulac. huttonii, n. sp., Gr. and St.
Aulac. janischii, n. sp., Gr. and St.
Aulac. janischii, Gr. and St., var. *abrupta*.
Aulac. margaritaceus, Ralfs.
Aulac. margaritaceus, Ralfs, var. *debyana*, Gr. and St.
Aulac. margaritaceus, Ralfs, var. *undosa*, Gr. and St.
Aulac. radiosus, n. sp., Gr. and St.
Aulac. rattrayii, n. sp., Gr. and St.
Aulac. sollitianus, Norm., var. *nova-zealandica*, n. var., Gr. and St.
Aulac. spectabilis, Grev.
Auliscus barbadensis, Grev.
Aul. cœlatus, Bail.
Aul. fenestratus, n. sp., Gr. and St.
Aul. grevillei, Jan.
Aul. hardmanianus, Grev.
Aul. inflatus, n. sp., Gr. and St.
Aul. lacunosus, n. sp., Gr. and St.
Aul. lineatus, n. sp., Gr. and St.
Aul. notatus, Grev.
Aul. oamaruensis, n. sp., Gr. and St.
Aul. propinquus, n. sp., Gr. and St.
Aul. pruinosus, Bail.
Aul. (pruinosus, var. ?) *confluens*, Grun.
Aul. punctatus, Grev.
Aul. punctatus, Bail., var.
Aul. racemosus, Ralfs.
Biddulphia chinensis, Grev.
B. dissipata, n. sp., Gr. and St.
B. elegantula, Grev.
B. (?) *fossa*, n. sp., Gr. and St.
B. lata, n. sp., Gr. and St.
B. oamaruensis, n. sp., Gr. and St.
B. pedalis, n. sp., Gr. and St.
B. podagrosa, Grev., var.
B. punctata, Grev.
B. reticulata, Roper, forma *trigona*.
B. tenera, n. sp., Gr. and St.

B. tuomeyii, Bail.
B. vittata, n. sp., Gr. and St.
B. (*Cerataulus ?*) *reversa*, n. sp., Gr. and St.
Brightwellia pulchra, Grun.
Campyloneis (*grevillei*, var. ?) *argus*, Grun.
Cerataulus johnsonianus (Grev.), Cl.
Cer. marginatus, n. sp., Gr. and St.
Cer. polymorphus, Kütz., forma *minor*.
Cer. subangulatus, n. sp., Gr. and St.
Chætoceras gastridium (Ehr.), Grun., var.
Clavicula aspicephala, Paut.
Cocconeis barbadensis, Grev.
Coc. costatata, Greg.
Coc. naviculoides, Grev.
Coc. nodulifer, n. sp., Gr. and St.
Coc. pseudo-marginata, var. *intermedia*, Grun.
Coscinodiscus angulatus, Grev.
C. bulliens, A. Schm.
C. centralis, Greg.
C. concavus, Greg., nec Ehr.
C. curvatulus, Grun.
C. decrescens, Grun.
C. eccentricus, Ehr.
C. elegans, Grev.
C. elegans, Grev., var. *spinifera*, Gr. and St.
C. griseus, Grev., var. *galopagensis*, Grun.
C. inequalis, n. sp., Gr. and St.
C. kützingii, A. Schm.
C. marginatus, Ehr.
C. minor, Ehr.
C. nitidus, Greg.
C. oamaruensis, n. sp., Gr. and St.
C. oblongus, Grev.
C. oculus iridis, Ehr.
C. radiatus, Ehr.
C. radiosus, Grun.
C. rothii, Grun.
C. scintillans, Grev.
C. subtilis, Ehr.
C. subtilis, var. *symbolophora*, Grun.
Cosmiodiscus normanianus, Grev.
Craspedoporus elegans, n. sp., Gr. and St.
Dicladia capreolus, Ehr.
Dimeregramma fulvum (Greg.), Ralfs.
Donkinia antiqua, n. sp., Gr. and St.
Entogonia davyana, Grev.
Eunotogramma (?) *bivittata*, Grun. and Paut.
Eunotogramma weissei, Ehr., var. *producta*, n. var., Gr. and St.

Euodia janischii, Grun.
E. striata, n. sp., Gr. and St.
Gephyria incurvata, Arnott.
Glyphodesmis marginata, n. sp., Gr. and St.
Glyphodiscus scintillans, A. Schm.
Glypho. stellatus, Grev.
Goniothecium odontella, Ehr.
Grammatophora oceanica, Ehr.
Hemiaulus amplectans, n. sp., Gr. and St.
Hem. amplectans, var. *major*, n. sp., Gr. and St.
Hem. angustus, Grev.
Hem. barbadensis, Grun.
Hem. dissimilis, n. sp., Gr. and St.
Hem. includens (Ehr.), Grun.
Hem. lyriformis, Grev.
Hem. ornithocephalus, Grev.
Hem. polymorphus, Grun.
Hem. (?) *tenuicornis*, Grev.
Hyalodiscus arcticus, Grun.
Hyal. radiatus (O'Meara), Grun.
Hyal. subtilis, Bail.
Huttonia alternans, n. gen., n. sp., Gr. and St.
Hutt. virgata, n. gen., n. sp., Gr. and St.
Isthmia enervis, Ehr.
Kittonia elaborata, n. gen., n. sp., Gr. and St.
Kitt. virgata, n. gen., n. sp., Gr. and St.
Lampriscus (?) *debyii*, n. sp., Gr. and St.
Liradiscus ovalis, Grev.
Mastogloia reticulata, Grun.
Melosira borreri, W. S.
Mel. clavigera, Grun.
Mel. oamaruensis, n. sp., Gr. and St.
Mel. sol, (Ehr.), Kütz.
Mel. westii, W. S.
Nitzschia antiqua, n. sp., Gr. and St.
Nit. grundlerii, Grun.
Navicula apis, Ehr.
Nav. biconstricta, n. sp., Gr. and St.
Nav. braziliensis, Grun.
Nav. decora, n. sp., Gr. and St.
Nav. definita, n. sp., Gr. and St.
Nav. dispersa, n. sp., Gr. and St.
Nav. gemmata, Grev.
Nav. (*Alloneis?*) *grundlerii*, Cleve and Grun.
Nav. inelegans, n. sp., Gr. and St.
Nav. interlineata, n. sp., Gr. and St.
Nav. margino-lineata, n. sp., Gr. and St.
Nav. margino-punctata, n. sp., Gr. and St.

Nav. placita, n. sp., Gr. and St.
Nav. prætexta, Ehr.
Nav. sandriana, Grun.
Nav. smithii, var. *nitescens*, Greg.
Nav. sparsipunctata, n. sp., Gr. and St.
Nav. spathifera, n. sp., Gr. and St.
Nav. trilineata, n. sp., Gr. and St.
Orthoncis splendida (Greg.), Grun.
Paralia sulcata (Ehr.), Cleve (*Orthorisa marina*, "S.B.D.").
Plagiogramma (*constrictum*, var ?) *nancoorense*, Grun.
Plag. neogradense, Pautocsek.
Plag. tesselatum, Grev.
Podosira hormoides (Mont.), Grun.
Pod. maxima, Kütz.
Porodiscus hirsutus, n. sp., Gr. and St.
Por. interruptus, n. sp., Gr. and St.
Pseudo-rutilaria monile, n. sub-gen., n. sp., Gr. and St.
Pyxidicula cruciata, Ehr.
Pyxilla dubia, Grun.
Pyx. johnsoniana, Grev.
Pyx. reticulata, n. sp., Gr. and St.
Pyx. (?) (*Pterotheca*, Kitt.) *aculeifera*, Grun.
Rutilaria epsilon, Grev.
Rut. epsilon, var. *tenuis*, n. sp., Gr. and St.
Rut. lanceolata, n. sp., Gr. and St.
Rut. radiata, n. sp., Gr. and St.
Stephanogonia danica (Kitt.), Grun., var.
Stephanopyxis barbadensis (Grev.), Grun.
St. ferox (Grev.), Grun.
St. grunnowii, n. sp., Gr. and St.
St. turris (Grev.), Grun.
St. turris, var. *brevispina*, Grun.
(And numerous other forms belonging to *Stephanopyxis*.)
Stictodesmis australis, Grev.
Stictodiscus californicus, Grev., var. *areolata*, Grun.
Stict. californicus, var. *nitida*, n. var., Gr. and St.
Stict. hardmanianus, Grev., var. *megapora*, n. var., Gr. and St.
Stoschia (?) *punctata*, n. sp., Gr. and St.
Synedra crystallina (Ag.), Kütz.
Terpsinoe americana, Bail.
Terpsinoe americana, Bail., forma *trigona*, Pautoc.
Triceratium americanum, Ralfs.
T. americanum, var. *quadrata*, n. var., Gr. and St.
T. arcticum, Bright.
T. arcticum, var. *permagnum*, Janisch.
T. arcticum, Brightw., forma *quinquelobata*.
T. ausliscoides, n. sp., Gr. and St.
T. barbadense, Grev.

T. bimarginatum, n. sp., Gr. and St.
T. capitatum, Ralfs.
T. castellatum, West.
T. concinnum, Grev.
T. condecorum, Ehr.
T. cordiferum, n. sp., Gr. and St.
T. coscinoide, n. sp., Gr. and St.
T. coscinoide, var. *quadrata*, n. sp., Gr. and St.
T. crenulatum, n. sp., Gr. and St.
T. crenulatum, forma *gibbosa*, n. sp., Gr. and St.
T. denticulatum, Grev.
T. divisum, Grun.
T. dobreèanum, Grev., var. *nov.-zealandica*, n. var., Gr. and St.
T. eccentricum, n. sp., Gr. and St.
T. exornatum, Grev.
T. favus, Ehr.
T. favus, var. *quadrata*, Grun.
T. favus (Ehr.), var. *pentagona*.
T. grande, Brightw.
T. grande (B.), forma *quadrata*.
T. harrisonianum, Norm. and Grev.
T. inelegans, Grev., var.
T. intermedium, n. sp., Gr. and St.
T. kinkerianum, Witt.
T. lineatum, Grev.
T. lineatum with two processes, Grev., var.
T. lobatum, Grev.
T. montereyii, Brightw.
T. morlandii, n. sp., Gr. and St.
T. neglectum, Grev.
T. nitescens, Grev.
T. oamaruense, n. sp., Gr. and St.
T. obesum, Grev.
T. papillatum, n. sp., Gr. and St.
T. parallelum (Ehr.), Grev., forma *trigona*, A. Schm.
T. parallelum, forma *trigona*, var. *gibbosa*, Gr. and St.
T. parallelum, forma *quadrata* = *Amphitetras parallelum* (Ehr.), Grev.
T. plumosum, Grev.
T. pseudo-nervatum, n. sp., Gr. and St.
T. rectangulare, n. sp., Gr. and St.
T. repletum, Grev.
T. rotundatum, Grev.
T. rugosum, n. sp., Gr. and St.
T. sexapartitum, n. sp., Gr. and St.
T. shadboltianum, Grev.
T. spinosum, Bail., var. *ornata*, n. var., Gr. and St.
T. stokesianum, Grev.

T. trisulcum, Bailey.
T. unguiculatum, Grev.
T. venosum, Bright.
T. venulosum, Grev., var. *major*, n. var., Gr. and St.
T. weissii, Grun.
T. weiseflogii, n. sp., Gr. and St.
T. parallelum (Ehr.), Grev., with seven angles, Gr. and St.
T. parallelum (Ehr.), var. *gibbosa*, forma *ovalis*, Gr. and St.
Trinacria ligulata (Grev.), Gr. and St.
Trin. pileolus, var. *gutlandica*, Grun.
Trin. simulacrum, n. sp., Gr. and St.
Trin. ventricosa, n. sp., Gr. and St.
Xanthiopyxis oblonga, Ehr.
X. constricta, Ehr.

ART. XXXIV.—*Notes on a Deposit of Moa-bones in the Te Aute Swamp, Hawke's Bay.*

By A. HAMILTON.

[*Read before the Hawke's Bay Philosophical Institute, 9th July and 11th September, 1888.*]

IN this short paper I purpose bringing before you a few particulars with regard to the occurrence of the remains of the great extinct birds commonly known as moas in this island, with more especial reference to the localities in which I have myself obtained their remains.

There will be no necessity for me to do more than call to remembrance that our President (W. Colenso, F.R.S.) and the Rev. W. Williams, of Waiapu, were among those who had the pleasure and privilege of submitting the bones collected by them on the east coast of this island to Professor Owen, from which material his famous memoir was drawn up. In other memoirs the venerable professor has described collections made at various localities on the west coast, under the shadow of Mount Egmont, by Mr. Mantell; and in his classic work Von Hochstetter describes his arduous pursuit of fragmentary bones, and his delight at obtaining some specimens at Tuhua.

It would be hopeless to attempt to record all the localities at which finds of moa-bones have taken place, but I trust that the instances which have come under my personal observation, and which I bring before you to-night, will demonstrate the great length of time during which the moa was the absolute monarch of this land, roaming over this district in a perfect avian paradise, for, with the exception of the giant eagle (*Harpagornis*), there was no enemy of any kind to harass or

destroy them, unless we admit that the natives at a comparatively recent time assisted in their extermination, thereby hastening the final disappearance of a group of dinornic birds, which had inhabited an isolated land-area of limited extent for such a length of time as sufficed for the development of at least twenty well-defined forms or species, a large proportion of which it will be seen were co-existent in this district.

Mr. Park, in the Geological Reports for 1887,* gives an instance of the finding of bird-bones in the brown sands near Kai-iwi, Wanganui, by Mr. Drew, an energetic collector in that district; and goes on to say, "On examination they were identified as belonging to the latter" (small moa). This, I believe, is the first discovery of fossil moa-bones in New Zealand. When I arrived in Napier some years ago, Mr. F. Williams kindly showed me a block of sandy clay containing a well-preserved femur of a moa, and also several fragments of bone and some large pieces of egg-shells, all from one locality. He stated that they had been dug out of a cliff on the shore of the Inner Harbour, at an island called Te Ihu te Otere. These specimens were then sent to the Colonial Museum, at Wellington, where I saw them a short time ago. I visited the place where the bones were found soon afterwards, and succeeded in finding several fragments of bone and plenty of egg-shell.

The bones are found in the face of a high cliff formed of the Petane marls, and lie, together with a few large pebbles or shingle, at the bottom of a small valley of denudation which has been filled in by subaerial formation similar to the Petane clay and sand, containing fragments (blown?) of *Pecten novæ-zealandiæ* and great numbers of two small land-shells, *Therasia thaisa* and *Helix rotundata*. This filled-up valley has been cut through at right angles by the denuding action of the waves, which has determined the present coast-line of the harbour and bay. The height from the top of the cliff to the bottom of the synclinal trough thus exposed is about 90ft., a few feet at the top of the cliff being the prevalent superficial pumice of the district, and which caps most of the high country.

At one of my visits to this interesting locality I found a large block had fallen to the sea-level or beach (which is here about 10ft. or 12ft. below the moa-bones), and on one face of it I found a small femur which corresponds exactly with the figure given by Owen of that of *Notornis mantelli*: this I dug out carefully, and it is now in our Museum. Nearer the surface of the water, where the boring crustaceans had begun to riddle the block, I saw traces of egg-shell, and, examining it

* "Rep. Geol. Surv. of N.Z.," 1887, p. 63.

more closely, found that there were two regular layers extending over a considerable distance. Having cut out a large piece of the block, I brought it home, and you can now see on the table before you a fossil moa's egg. The egg has evidently been flattened, and thus shows two layers of shell extending all round the block more or less continuously.

Owing to the nature of the cliff it is impossible to make any further excavation in this place, although many fragments of bone and bits of egg-shell indicate that the bottom of this old gully yet contains many bones.

The Marine Parade of Napier does not seem a very likely place for moa-bones, but at the end of the Coote Road the sea cuts into a deposit of brick earth or loëss, which abuts sharply against the Limestone Bluff. The upper part of the section exposed is full of *débris* from the Bluff Hill; but below this, and more towards the steps, bird-bones of various sizes are occasionally to be found, and sometimes a moa-bone. I had the pleasure of showing one *in situ* to Dr. Hector when he was here in 1878: since then several have been exposed. I have seen one within the last month. At the foot of the hills between Pakipaki and Mr. Douglass's station are some very deep creeks, coming from the limestone hills and cutting through slope-deposits and flood-silts. In one of these creeks I obtained about a dozen good moa-bones. In a valley of the Greenmeadows Estate, close by the Puketapu road-cutting, a large number of moa-bones in a very fragmentary condition were found when the swamp was drained and the ground first broken up. I was fortunate enough to get a few good bones of a small species of moa and some bones of the extinct eagle (*Harpagornis*).

Another very interesting locality, about which I hope to have something to say some day in detail, is the sea-beach near the woolshed at Waimarama. Here the beach is often swept of the sand by the waves right down to the blue clay, in which are seen stumps and roots of trees and moa-bones. Mr. Hill and I, the last time we rode by there, saw about half an acre of blue clay thickly studded with bones, all in too rotten a state to bear removal. Many bones have been got from the creek which here runs into the sea.

I have dug out a stout femur from the cliff on the north side of the Waikare River, near Mohaka; and in the Museum are four very fine bones which were found in the Poutou Creek, in the same neighbourhood.

This brings us to surface-finds, and here I must note some very large but much-decayed bones found by Dr. Hector in the Raukawa Bush, now in our Museum. They were found on the surface, but all the small bones had disappeared. Mr. Pine, of Raukawa, and myself found several good moa-bones in a creek

which drains a large swampy valley near the Raukawa Station, and I am in hopes that some day a large deposit of bones may be found there.

Away up the Tutaekuri River is a large tributary called the Mangahone. Here one of our members, Mr. Taylor White, has found some more or less perfect bones. Still further up the same river, at Glenross, Mr. Balfour has sent us down moa-cropstones and bones of kiwi and moa. Several bones have been picked up from time to time in the bed of the Petane River, and a femur and two or three vertebræ were dug from a small swamp close by the Petane School.

One rather interesting find was a tibia found by me just at the edge of the bush at Takapau. The bone was in the bed of a small creek, and, though in good preservation, one-half was thickly covered with moss.

With the exception of the last-mentioned and the bones from the Poutou Creek, all the bones recorded were too imperfect to be of much use; but, fortunately, others have been found in a most exceptional state of preservation and of great scientific interest. One day I was shown a very fine tibia which had been found at Patangata: this was in the possession of a gentleman at Waipawa. I then saw an equally good one in the possession of our President from the same neighbourhood, and on further inquiry heard that a large number of bones had been found during the works which were being carried out for the drainage of the Te Aute Lake. The Rev. S. Williams (now Archdeacon of Hawke's Bay) very kindly allowed me to examine the bones which had been preserved, which I found indicated the occurrence of a large number of moas, many of them of gigantic size, the length of one tibia being 37½in., only a trifle short of the largest specimen hitherto recorded. During the last summer the progress of the great drain enabled me to examine the locality carefully, and, through the courtesy and kindness of the Rev. S. Williams and Mr. Allan Williams, I was able to secure a most interesting collection of bones, some of which are now before you. The spot where the bones were found is at the south-east end of the large tract of swampy land which surrounds the lake. The overflow from this area, which was frequently flooded to a considerable depth by a channel cut by the Waipawa River, was carried off by a small creek or stream which rejoined the main river at Patangata. A deep channel was blasted through a bar of limestone rock which formed the end of a low ridge of hills forming the eastern boundary of the swamp. By lowering this outfall and cutting a great drain nearly two miles long, the whole of the swamp has become passable, and will shortly be carrying a very large number of cattle and sheep.

Mr. Allan Williams kindly took me to the drain, and the

foreman showed me the place where the bones had been found most plentifully. A slight examination showed that there were plenty more bones to be got. I decided on excavating for them.

The spot where the bones were found is just at the very mouth of the drain, where it empties itself into a very deep pool, of which the rock-barrier forms the further side. The section exposed in the cutting of the drain is about 15ft. deep, and is 8ft. or 10ft. of silt-deposit (pumice and washing from the cretaceous rocks of the district): then a forest-bed, consisting of trunks of trees and roots matted together—about 4ft.; from that downwards a stiff blue clay. It is in the lowest part of the forest-bed and in the stiff blue clay that the bones were found.

The line of the drain has passed over a spring round which the blue clay is so soft that it was impossible to stand very near to it.

I had two of the men who were working at the drain to help me, and we got quite interested in the work, as we found that in the clay under our feet at the bottom of the drain there were hundreds of bones. Having to work up to our middle in clay and water was certainly somewhat awkward; but, as every now and then an exceptionally fine bone was fished up, the discomfort was forgotten. The floor of the drain was not more than 10ft. wide, and, as the area over which we found the bones did not extend more than 15ft. up the drain, the number of bones recovered is certainly remarkable.

The appliances we had did not permit of as careful an examination as I could have wished, as many of the valuable small bones were undoubtedly lost and thrown down the talus slope into the deep pool, where there are undoubtedly many more, as we found out by accident. One of the shovels having slipped into the pool, we raked about for it as far down as we could put a long-handled rake, and at the first haul, instead of the shovel, up came a splendid tibia 32in. long. I hope to dredge this hole some day, and by washing the results through a screen shall probably get many of the smaller bones which I still require to complete the skeleton I am now restoring from the bones obtained.

It was from the first apparent that (as in the case of the Glenmark and Hamilton finds) no perfect skeletons would be met with, and I could observe very little sequence or order in the manner in which the bones were found deposited, the only point of interest being that most of the larger leg-bones were found in a vertical position, the tibia and metatarsus often in their relative positions. A sequence of eleven vertebræ of a large species was found in one part of the bank; but generally speaking the bones, great and small, were locked

together in great confusion. The men who assisted me were very careful in extricating the specimens, and very few were injured considering the difficulty of working under water, and in the stiff and extremely tenacious clay.

After two days' work at this place, and an examination of two places higher up the drain where a few bones had been found, we ceased operations.

Mr. Williams kindly had the spoils conveyed to the station, and the railway authorities kindly conveyed the bones to Napier free of charge.

The bones which I have referred to as having been got on the first cutting of the drain were also presented by the Archdeacon to the Museum, and sent down to Napier.

The cleaning, sorting, measuring, comparison, classing, and identification of more than a thousand bones and fragments has necessarily taken me some time, and I regret that I shall have to leave what will perhaps be the more interesting part of my paper till another occasion, on which I hope to enumerate the kinds and relative bulk of the species met with, and to draw your attention to the more striking features in the anatomy of the gigantic moas.

It may possibly be asked how can such an accumulation of bones in the one place be accounted for. This I hope to give a reasonable theory for in the next paper. At present the facts lead me to the conclusion that the most tenable hypothesis is that the spot was a narrow crossing-place in a swampy forest, and that the springs caused the ground to be so soft and swampy that moas were often bogged and unable to extricate themselves. The reasons in support of this I shall advance for your consideration.

P.S.—Within the last few days I hear that another find of moa-bones has been made in the same swamp. If such is the case I trust that the new discoveries will enable us to complete our series of the North Island forms of *Dinornis*.

In the notes which I had the honour to read to you at the July meeting, I gave some account of the deposit of moa-bones examined by me at Te Aute, and promised to continue the paper.

Just before our last meeting I paid another visit to the lake, and found that another discovery had been made in a spot nearly two miles from the original find.

It seems that when the drainage operations reached the actual shore of the lake itself the drain was continued in a straight line nearly half a mile into the lake, passing through the centre of an irregular winding lagoon forming the exit of the lake. The result of this was an immediate lowering of

the water in the lake, and the laying-bare of the whole of the winding lagoon, which was then seen to consist of a matted network of forest-roots and timber, together with innumerable seeds of hinau and manuka.

Lying on and among the roots were quantities of bones, which the foreman of the works, Mr. Pickett, carefully collected for me, and which prove of surpassing interest.

The bones were, as in the former case, nearly all in one small area, and, strange to say, just at the foot of a spur, as in the first find; but here they were lying on the surface, and were in a most wonderful state of preservation, young and old, great and small. One bone, an immature tibia, measures 35½in. The bones of the moas are in, as I said, a wonderful state of preservation; but by far the most interesting are the small bones which have been disclosed by this lowering of the water.

Although my identifications are not yet complete, I have got bones of the great extinct goose—the *Cnemiornis*—a breastbone quite perfect, the bones of the legs, and some of the wing-bones. In general, these bones are smaller than those found in the South Island.

Of the great extinct eagle (*Harpagornis*) I have several bones—amongst others an ungual phalanx, or claw-bone, and several tibiæ. This is extremely interesting, as I did not meet with this species in the other deposit.

The next treasure is a perfect lower mandible of *Notornis*. This gigantic rail can therefore be undoubtedly added to our list of Te Aute birds. I show you the life-sized drawing made from the specimen obtained by Mr. Mantell, now stuffed, and placed in the British Museum.

Many other bones occur, which I have not yet been able to recognise. There are three or four tibiæ (immature) of a large wading-bird as large as our white heron, or kotuku.

At the time of my visit the spot itself where the bones were found was under water, owing to the lake being filled up with the rain; but I could see the higher parts of the stumps and roots above water. On the level muddy floor of the lake, some chains from the edge, a very large pelvis was found quite exposed.

Without further investigation it would be rash to conclude that these bones are very recent. I think it more probable that they are of the same age as the bones at the rock, but that the action of the flowing water from the lake has removed the accumulation of vegetable matter in which they were buried, and left the bones entangled among the roots and timber.

Two points may be noticed in connection with this discovery:—

1. That the bones were a second time found collected at the end of a spur running into the swamp.

2. That there is again an unaccountable absence of skulls and neckbones.

Art. XXXV.—*Discovery of Fossil Moa-feathers in Rocks of Pliocene Age.*

By H. Hill.

[*Read before the Hawke's Bay Philosophical Institute, 12th Nov., 1888.*]

I beg to bring under the notice of the Society a very interesting discovery made by me a few days ago. I refer to the finding of excellent specimens of fossil feathers in rocks, which I think are pliocene, and, indeed, are so classed by the Geological Survey Department.

The place where the fossils were found is situated at Ormond, about ten miles north-west from Gisborne, in the Poverty Bay district. A range of hills bounds the northern part of the Poverty Bay plain. This range extends from the coast in a north-west direction, passing behind the Ormond township, and continuing to a point five miles or so further to the north-west, where it is cut through by the Waipaoa River, which empties itself in the bay. The hills behind Ormond, where the fossils were found, must be about 350ft. above sea-level. They are composed of blue clays, coarse sandy fossiliferous limestones, and pumice mud and sands, the latter being the highest beds. All the beds appear to rest conformably on one another, and they agree in stratigraphical arrangement with the beds exposed in a high bluff on the Whataupoko, opposite the town of Gisborne. The pumice-mud deposit is one of great interest, as it is from this deposit, which must be at least 100ft. in thickness, that the fossil feathers were obtained, together with a large collection of beautifully-preserved leaf-impressions, ferns, seeds, fishes (vertebrates), crabs, and other interesting specimens.

The pumice-mud is of a creamy whiteness, clayey to the touch; is free from grit of any kind; can be used like chalk for writing; can be slit like slate into thin plates, which will bend without fracture; and, lastly, it has a slaty cleavage. In places, however, the rock passes into coarse pumice-sand, and in others it becomes indurated, and has the appearance of a siliceous sinter. Last year, in a paper on the "Distribution of Pumice along the East Coast,"* I referred to this deposit as

* "Trans. N.Z. Inst.," vol. xx., p. 293.

having found in it many varieties of fossil leaves, and it was then referred to by me as corresponding to the Kidnappers conglomerate and pumice-beds, which, in my opinion, form the youngest of the pliocene deposits in this district.

Professor Hutton, in vol. iv. of the "Transactions," gives a description and an illustration of a moa-feather, and in several particulars two of the feathers found by me in the above beds agree with the description referred to. Unfortunately, the top ends of two of the best specimens are missing. The feathers are about 4in. long, and the barbs are unconnected, as in the case of struthious birds. The barbules can be seen, but there are no other traces of bifurcations, nor is there any accessory plume, as in the case of many specimens of moa-feathers now known. The feathers differ from any of the illustrations in the "Transactions" in their being broader, in the basal part of the shaft being thicker, and possibly in the absence of barbs at the basal end, these not showing at the point where the shaft is broadest.

The other feather which I have is not such a perfect specimen as the above, and it appears to be of a different kind. It is about 2½in. in length, and is bent not unlike the small side-feathers to be seen in the Prince of Wales plume.

I do not think there can be any doubt as to the feathers here described having once belonged to a moa, and if such be the case it will place the history of that bird much further back in geological time than has hitherto been recognised. No scientific question has been more sturdily discussed in our "Transactions" and elsewhere than the date of the disappearance of the moa in New Zealand, one party maintaining that the moa has been so long extinct that no reliable traditions have been handed down, whilst yet another party supports the view that the moa became extinct in comparatively recent times. The case, however, is yet undecided, and we must wait for further evidence on this interesting subject before a final judgment can be entered. But in the long discussion which has been carried on no one, as far as I am aware, has hitherto produced any evidence likely to call in question the statement put forth by the late Sir Julius von Haast to the effect that "different species of *Dinornis* or moa began to appear and flourish in the post-pliocene period of New Zealand."* The generalisation made by Sir Julius was based upon a wide experience and knowledge of the remains of moas found throughout the country, but it would seem to have been made without due consideration as to what the future testimony of the rocks might be on the subject.

The discovery of fossil feathers in pliocene beds offers suffi-

* See "Trans. N.Z. Inst.," vol. iv., p. 106.

cient evidence to prove the existence of struthious birds in this country anterior to the limit fixed by the late Sir Julius von Haast, but it does not follow that yet older remains or traces of the moa may not be found. The discovery has placed the geological record of the life-history of the moa one step farther back. It has extended the period of its existence in the country, and it has opened out the fact that in the matter of climate and productions the country has changed but little. Most of the varieties of leaves found with the feathers belong to species still common in the North Island. Some, however, are new, but further treatment of the subject must be deferred until a detailed description of the fossil flora and fauna can be obtained from those more capable than myself of expressing a judgment on these matters.

Art. XXXVI.—*The Oil Prospects of Poverty Bay and District.*

By H. Hill.

[*Read before the Hawke's Bay Philosophical Institute, 12th Nov., 1888.*]

Plate XXIV.

During the present year a good deal of interest has been aroused throughout New Zealand and the neighbouring colonies by the reported "striking of oil" at one of the many springs which are to be found along the east coast of this island. It is now twenty-three years since the first reported discovery of oil in the Poverty Bay district was made known in Napier. Ten years ago I visited the site of an abandoned well in the vicinity of Poverty Bay, where it had been anticipated that oil would flow like water; but at that time few traces remained of what had once been a scene of activity and hope. Since the date of my visit a number of attempts have been made to find a payable field in several places, but without success until early in the present year, when news reached Gisborne that oil had been struck in a new sinking, and that the engine-house, derrick, and adjoining buildings had been destroyed by an explosion of gas and oil from the new well.

Being in the Poverty Bay district shortly after the reported "striking of oil," I took the opportunity to visit the site of the South Pacific Company's well, so that I might judge for myself whether the oil prospects are equal to what had been reported in the papers. The locality of the South Pacific Company's well, and of another well in course of sinking, and known as the Minerva Company's well, is about twenty-eight

miles from Gisborne in a north-west direction, and at a height of about 450ft. above sea-level. The well belonging to the former company is situated on the Wairangamea Stream, five miles above its junction with the Waipaoa River, which empties its waters into Poverty Bay. The Minerva well is situated on the Waipaoa River, a mile or so to the west of the Pacific Company's well. Work had been stopped at the Pacific Company's well at the date of my visit, but I was enabled nevertheless to gather a good deal of information from the gentleman in charge, who is an experienced American well-sinker. As already remarked, the engine-house and derrick at this well had been destroyed, and in order to provide against further accidents a cap had been fixed on the pipe or tube-bore of the well, and this was kept locked. This cap was taken off, and I saw for the first time an oil-well, having a pipe or tube 6in. in diameter, and passing down into the earth more than 1,300ft., and as far as one could judge it was full of oil to the brim. Specimens of the oil were obtained by me, and I have no doubt whatever that they are genuine.

The oil appears of a grey-amber colour when held against the light, and its specific gravity in its crude state is greater than the American oil. As to its illuminating qualities, it is impossible to speak with certainty, but the tests hitherto made have been very satisfactory. The exact depth of the well is 1,321ft. This is the depth at which oil has been struck, so that the oil-rock or oil-beds are about 870ft. below sea-level. The oil in the tube rises 3ft. or so above the surface, but, curiously, the height varies according to the direction of the winds and the character of the tides. Before the great eruption at Tarawera when the terraces were destroyed it was noticed that one of the *great cauldrons* of boiling water varied in its intensity according to the direction of the winds, and we know as a fact that the artesian wells in Hawke's Bay rise about 2ft. higher at high tide than at low tide. It hardly seems credible that wells—and those oil-wells—so far from the sea could be influenced by the action of the tides, as is the case with our local artesian wells; but such would appear to be the case: this could only be possible, as far as I can judge, on the supposition that the oil-bearing strata are similar in arrangement and plan to an artesian basin.

When the explosion took place in the well under notice the tools were lost, and they have remained in the well ever since. When the machinery is once more in working-order, and the tools have been recovered, it may be that the boring-tool will be able to penetrate still further into the oil-bearing strata, and that the flow will be largely increased; for unless the well be a flowing one I do not see how it is possible to make it a paying concern, which, after all, is the practical test

of the capitalists. The sinking at the Minerva well has not reached more than 750ft., but the prospects are reported as being good, and the working manager anticipates reaching the oil-beds at 1,000ft., or 1,100ft. at the furthest. I fear the manager is too sanguine on this point; but in any case the working of this second well, and of a third well midway between the Minerva and Pacific Company's wells, will provide data of great importance as to the dip and character of the oil-bearing strata along the east coast. At present everything in connection with the oil industry is tentative. Facts have to be gathered together and careful observations made before inferences can be drawn as to the future success of the east coast as an oil-producing district. But the subject is of special interest to this colony, for the question as to the employment of petroleum as a fuel is growing into prominence every day, and I look upon it that no opportunity should be lost by the Government in providing for the accumulation of facts and statistics bearing on the question of sinking and the production of oil, which might prove of great value in the near future.

The east coast district north of the Kidnappers is mainly composed of rocks of tertiary age, and it is among the tertiary rocks that evidence is forthcoming as to the existence of oil.

In America the oil is found in the silurian rocks; but in Burmah, in Galicia, in Austria, in France, and in the celebrated district south of the Caucasus, the oil is found in rocks of tertiary age, as in this country.

As far as I can judge from the sections (see Plate XXIV.), the sinking at the South Pacific well shows no rocks except tertiary; but it is a curious circumstance that what are known in the American oil-fields as the first, second, and third sand-rocks are reported as having been passed through in the South Pacific well, and latterly in the Minerva well. These sand-rocks vary in structure, depth, and thickness in the different localities of the American oil-regions, but from each bore oil is obtainable, the best flow, though not the most valuable oil, being in the third or lowest sand-rock. The manager of the South Pacific well has had an extensive experience in America, but he is no doubt mistaken, notwithstanding, as to the similarity between the sand or oil-producing beds in America and the rocks passed through in this country. There may be some likeness between the sand-rocks, or what are called sand-rocks by some oil-sinkers, in America and in the Poverty Bay district; but in America the sand-rock is the true oil-bearing rock, whilst in the South Pacific well, according to the sections shown on the manager's plan, the so-called sand-rocks simply

gave a show of gas and oil where passing through them, and oil has been struck 170ft. below the third sand-rock, as shown by him. No instance, as far as I am aware, has as yet been found of oil below the third sand-rock.

Between the American oil-wells and that sunk by the South Pacific Company there is one point of similarity worthy of special notice. In all the American wells brackish or salt water is found immediately overlying or in connection with the oil. The two liquids have been found in almost immediate contact very generally in the first, second, and third sandstone (?), the rule being in some districts "No brine, no petroleum," for while the brine usually manifests itself first in order when the pump is applied, it never forsakes the oil; the two clinging to each other like brother and sister. I understand that similar appearances are met with in Burma and in Galicia, but whether they occur in France or in the district south of the Caucasus I have been unable to ascertain.

At the South Pacific well salt water was everywhere met with below 470ft., so that in this particular the appearances are encouraging. The existence of brackish water along with oil is of great interest as probably giving a clue to the extent of the oil-bearing strata along the east coast. I have watched for a long time past, as opportunity offered, a number of salt springs which are to be found scattered over a large extent of country extending from the Mahia Peninsula to Poverty Bay, and thence onward north-west or north-north-west in the direction of the oil-wells. These springs resemble miniature volcanic cones, the crater being occupied by water and mud instead of lava. This water rises and falls as the gas-bubbles rise to the surface, and the bursting of the bubbles causes a bluish-grey mud to be thrown out, which forms a conical mound of bare ground. The gas-bubbles explode if a lighted taper is held over the surface of the water just as they rise to the top. At Tua Motu, near Gisborne, and on what is known as the Kaiti Block, the springs are somewhat numerous; and inland, some miles to the west of Wangara, fifteen miles or so north of Gisborne, very large salt springs are met with.

The appearances observable in the oil-fields of different localities and countries may prove by comparison of great value in discussing the prospects of the east coast as an oil-producing district. Surface-appearances may not afford proof positive that payable oil will be struck, nor is it to be expected that they should; but they may be indicative, nevertheless, of similar causes operating to produce the appearances: and it seems to me that the origin of the oil may by this means be inferred. Many theories have been put forth as to the origin of oil, one being that it results from the distillation of vegetable remains not yet turned into coal, another that it

is produced from the destructive distillation of coal, another that it is derived from the animal remains collected at the bottom of seas; whilst latterly a chemist has put forth the theory that oil is purely a mineral product, that it is due to the action of water on masses of carburets of metal, chiefly iron, at high temperatures far down in the earth, and that its production is going on day by day.

It is well known, however, that oil is found in the tertiary rocks in close connection with lines of volcanic phenomena. In the oil-region of Burma mud-volcanoes and hot springs are met with in close proximity to the oil, and it is certain that similar phenomena have been seen to the south of the Caucasus, between Baku and Tiflis, since the days of Marco Polo, who in his book of travel refers to a well of flowing oil suitable for use as lamp-oil.

Now, there are hot springs and mud-cones within the limits of the oil-wells of the east coast district; and, although these may probably exist in the absence of an oil-field, they still form what may be termed very favourable indications as far as the district under notice is concerned. But the indications grow in importance in face of the fact that oil has been struck; and the time may not be distant when the position of hot springs, salt springs, and mud-cones may become of commercial importance, for the reason that wherever the salt springs and mud-cones are found the rocks are identical with those where the oil-wells are situated. It is true that the country north of the Mahia Peninsula is rough and broken in places, and great flexures are to be met with on the coast to the north of Poverty Bay; but I see no reason why oil should not exist in basins as in the case of artesian wells, and flow accordingly. I am aware that flowing oil-wells are supposed to be due not to hydrostatic pressure, like an artesian well, but rather to the elastic force of the gas (carburetted hydrogen) which accompanies the oil in the majority of the wells; but this does not appear to be essential in the case of all flowing wells, and it is clear that some flowing wells must be due to hydrostatic pressure.

The east coast oil-district is surrounded by enormous beds of porous fossiliferous sandstones, which trough under Poverty Bay and underlie all the younger tertiaries, and it may be that these sandstones are the oil-bearing rocks of the district. At present, however, the data available are not sufficient to affirm with any degree of certainty either the character of the oil-beds or the actual existence of a payable oil-field; but, still, the prospects are encouraging and are worthy of careful attention even from a geological standpoint. The Minerva well is now within 300ft. of the oil-bearing strata, and another well is being put down at the point where the

Wairangamea Stream enters the Waipaoa River. Should these wells strike oil—as there is every prospect of their doing—the undertaking will be in a great measure assured, for facts will be available of much geological value, and the east coast district will have a great future before it.

The sections accompanying this paper (Pl. XXIV.) show the character of the rocks passed through at the South Pacific Company's well. The thickness of the several sections is also given, as taken from the working-sheets of the manager in charge, who kindly placed all available information at my disposal.

ART. XXXVII.—*On the Extent and Duration of Workable Coal in New Zealand.*

By JAMES PARK, F.G.S., of the Geological Survey Department.

[*Read before the Wellington Philosophical Society, 12th Sept., 1888.*]

AT the present time, when the Australian Colonies are looking to New Zealand for their supplies of coal, it may be of some interest to consider what position we are in to meet this new demand. I hope to be able to show that, whatever may be said as regards the extent of our metalliferous deposits, we are at least supplied with an abundance of fossil fuel sufficient to meet all our requirements for many years to come.

All the workable coals of this country belong to the Cretaceo-tertiary formation, of the Geological Survey classification, which consists in many places of two distinct groups of beds, differing widely in their mineral characters, in the general sequence of their strata, and in their fossil remains, the one being characterised by a fauna and flora with a distinctly Tertiary *facies*, the other by forms of an equally-pronounced Secondary type. The relation existing between these two groups of beds has not been very satisfactorily determined; but they are at present supposed by the Survey to be in a manner horizontal equivalents—that is, the result of contemporaneous deposition, the Tertiary strata being taken to represent the shallow-water and the Secondary strata the deep-water conditions of the same period.

How far this theory will meet the stratigraphical and palæontological difficulties of the case, considering that both these groups are sometimes found to exist in the same areas, I do not propose to discuss in this paper; it is of great importance, however, to note that, with one or two exceptions, all our workable coals occur at the base of the group with a Tertiary *facies*.

The age of our coal presents a marked distinction from that of the great coal-deposits of England, continental Europe, and North America, which occur in strata lying between the Old and New Red Sandstones. In the early part of this century so imbued were geologists with the idea that true coals were confined to this horizon that the coal-bearing strata received the age-name "Carboniferous," which is now generally applied to all rocks of this period, whether they contain carbonaceous deposits or not.

The subsequent discoveries of true coal in Lower Secondary strata in New South Wales, in Jurassic strata in India, and Upper Secondary strata in New Zealand, conclusively showed that, given the necessary geological conditions, coal could be formed at any period of the earth's history. Up to the present time no coal-seams have been found in rocks below the Devonian, and from this circumstance it is argued by some scientists that there must have been a scarcity of carbonic acid on the earth's surface prior to this period—too little, in fact, to favour the growth of great forests or dense vegetation of any kind. However true this may be of the Old World, it certainly does not apply to New Zealand. Among the Silurian schists and marbles of Western Otago, which are simply altered sandstones and limestones, there occur layers and nests of graphite under conditions which leave little room for doubt that they are the product of altered carbonaceous matter of vegetable origin.

It is now generally admitted that all coals rest on old soils or land-surfaces, and consist of nothing but vegetable matter. Judging from the leaf-impressions in the coal-shales, it is probable that our coals are principally the result of forest-vegetation of long-continued growth, among which dicotyledons are largely represented, and after these cycads, conifers, and ferns.

With one or two exceptions, the coal-deposits of this country occur near the base of the measures, which generally rest on the basement-rock of the district, showing that the forests grew on a long-persistent and comparatively stationary surface, with perhaps in most cases a tendency to a downward movement. After a period of rest, during which the carbonaceous matter accumulated, the land began to sink, and from the character of the estuarine and marine strata which cover the coal it can be ascertained that these old forests flourished on low-lying areas contiguous to the sea, or in deep estuaries or bays to which the sea had free access. The marginal or littoral character of our coal-areas can be seen at a glance by looking at the mineral map of New Zealand issued with the Geological Reports for 1886–87.

As a result of our coals having been formed on old land-

surfaces, the seams necessarily partake of all the irregularities of the land, and are consequently subject to great variations of thickness along the line of outcrop. It is also noticeable that where the land is steep the seams thin out rapidly to the dip.

It is a remarkable fact that, although the workable coals of New Zealand are all of the same age, they differ widely in their mineral characters and composition: for example, those of Otago are hydrated brown varieties, sometimes little better than lignites, while those of the west coast of the South Island are anhydrous or bituminous coals, mostly of fine quality, and in some respects superior to the coals from New South Wales. It should be stated, however, that the different varieties shade into each other: thus we have brown coals which exhibit an approach to semi-bituminous coals, which in their turn merge into true bituminous or caking-coals.

It would be difficult to define a dynamic agency competent to produce the metamorphism of the coals of the Grey and Buller coalfields, and at the same time so exclusive as to restrict its operations to these areas.

When this interesting question receives more attention, it will, I think, be found that the quality of the coal is largely influenced by the character of the enclosing strata: thus, when the measures are loose and porous the decomposition of the vegetable matter will probably result in the formation of lignites or hydrous brown coals, such as those of Otago; when greensands of a less pervious nature, a better class of coal will be formed, of which examples may be found at the Mokau, Waipu, Whangarei, and Kawakawa coalfields; and when heavy deposits of impervious fireclays, the result will be bituminous coals.

As the result of a large number of analyses in the Colonial Laboratory, Dr. Hector in 1872 classified the coals of New Zealand as follows:—

I. Hydrous (coal containing from 6 to 20 per cent. of permanent water)—
   - *a*. Lignite.
   - *b*. Brown coal.
   - *c*. Pitch-coal.

II. Anhydrous (coal containing less than 6 per cent. of water)—
   - *a*. Glance-coal.
   - *b*. Semi-bituminous coal.
   - *c*. Bituminous coal.

The workable coals come under three principal divisions—namely, (1) brown coal, (2) pitch-coal, and (3) bituminous coal. These varieties are distributed in what may be termed

geographical areas of deposition; thus, the brown coals occur principally in the eastern portion of the great axial division of the South Island, the bituminous coals in the west coast district of Nelson, and the pitch-coals in the North Island.

In preparing the following estimate of workable coal I have not included lignites, nor coals of any kind where the thickness of the seams is less than 2ft. These will no doubt be of great importance when the coalfields become exhausted; but until then they will have no market-value, and will probably be little sought for except for purely local consumption where other kinds of fuel are scarce:—

Brown Coal (Table No. 1).

Name of Coalfield.	Author of Estimate.	Amount of Coal in Tons.
Waikato	Hutton	140,000,000
Drury	From surveys by Cox ..	8,000,000
Waipa	Park	10,000,000
Kawhia	From surveys by McKay	4,000,000
Malvern Hills*	Lindop	17,089,000
Kakahu	Park	3,500,000
Oamaru-Waitaki	From surveys by McKay	2,000,000
Shag Point	v. Haast	1,000,000
Green Island and Saddle Hill ..	Denniston	74,700,000
Clutha-Tokomairiro	Hector	140,000,000
Wairaki	Hutton	100,000,000
Orepuki	"	5,000,000
Hokonui	Park	1,000,000
	Total	506,289,000

* The altered brown coals are included in this estimate.

Pitch-coal (Table No. 2).

Name of Coalfield.	Author of Estimate.	Amount of Coal in Tons.
Whangarei-Hikurangi ..	From surveys by Cox ..	20,000,000
Waipa	" ..	5,000,000
Mangawai	" ..	6,000,000
Mokauiti	Park	5,500,000
Mokau-Awakino	"	210,000,000
Upper Wanganui	"	50,000,000
West Wanganui	Hector	96,000,000
Tadmor and Hope	Park	10,000,000
Owen	"	2,500,000
Inangahua	From surveys by McKay	100,000,000
Maruia	" Cox ..	20,000,000
	Total	525,000,000

BITUMINOUS COAL (Table No. 3).

Name of Coalfield.	Author of Estimate.	Amount of Coal in Tons.
Kawakawa	From surveys by McKay	2,500,000
Pakawau	" Cox ..	2,500,000
Collingwood	" " ..	1,500,000
Mokihinui	Hector	3,000,000
Buller	Cox and Denniston ..	140,000,000
Grey	Hector	37,500,000
	Total	187,000,000

Total amount of coal—	Tons.
Brown coal	506,289,000
Pitch-coal	525,000,000
Bituminous coal	187,000,000
Total	1,218,289,000

After all necessary deductions for losses in working, &c., the total quantity of available coal may be set down at a thousand millions of tons, which at the present market-value of coal would represent about £750,000,000.

Until actual surveys are made, the above figures must only be looked upon as approximate estimates, but in most cases they are well within the mark. Most of the coal is level-free, and only such seams as are workable at the present time have been included in these returns. Ample allowances have also been made for areas of coal removed by denudation.

In addition to the coalfields mentioned in the above tables, small patches of coal-bearing measures occur at Takaka, Baton, Tiraumea, Karamea, and Lyell Mountains, in Nelson; at Waihaoa and Waipara, in Canterbury; and at Preservation Inlet in Otago.

Several thin seams of bituminous coal, ranging from a few inches to 15in. in thickness, occur in Jurassic rocks at the Hokonui Range, Waikawa, and Mataura. At the two former places prospecting operations were at one time undertaken to prove the extent of the coal, and quite recently a bore 131ft. deep has been put down at Rocklands, near Fortrose, with the same object. The seams in this formation are everywhere too thin to work, and, judging from the rapidly-alternating character of the strata, the land-movements at this period were too frequent to permit of the accumulation of large carbonaceous deposits, and for this cause little hope can be held out of thicker seams being found at these places.

Having determined the probable quantity of coal contained in our coalfields, we now arrive at the important problem,

How long may such quantity of coal be reasonably expected to last?

If we turn to the records of our output since 1878, we shall find that the total quantity of coal raised in the colony in that year was 162,218 tons, and in 1881 337,262 tons, which is equal to an increase of 100 per cent. in three years. During the last seven years the growth of the output has been slower, and shows something of a geometrical or proportional rate of increase.

The latest and highest recorded output—that of 1887, amounting to 558,620 tons—bears but a small proportion to our vast stores of coal, which in fact contain the former 2,181 times. But a little consideration will show that it would be absurd to speak as if we had enough coal to last for more than two thousand years, since the present rate of consumption is not a fixed but a growing rate.

The production of coal in Great Britain in 1887, according to the reports of the Inspectors of Mines, was 162,119,812 tons, which is contained in the total estimated available quantity of coal—amounting to 146,480,285,398 tons, as determined by the Royal Coal Commission in 1866—no less than 903 times. With this material it has been estimated by various authorities that the coal of Great Britain must be exhausted at periods ranging from eighty to one hundred and fifty years from the present time.

In New Zealand the coal industry is still in its infancy, and it is in consequence impossible at the present stage of our output to determine whether the rate of our increase is geometrical or arithmetical.

It is obvious that the output is governed by two causes—first, the natural increase of our population, and, second, the growth of capital applied to the development and extension of our manufactures.

Starting from the actual output in 1887, the output at intervals of ten years up to 1957 would be as follows—assuming that the increase of output continues uniform with the average yearly increase for the last seven years, which is sufficiently near for our purpose:—

	Tons.
1887 (actual output)	558,620
1897 (calculated output)	910,000
1907 "	1,471,500
1917 "	2,397,000
1927 "	3,905,000
1937 "	6,503,000
1947 "	10,598,000
1957 "	17,250,000

On the assumption that the facts of the past seven years supply adequate indications of the law of consumption of the

future, we arrive at the conclusion that in 1957—that is, sixty-nine years hence—our output would be thirty times its present amount, and that something like a third of the coal existing on these islands would by that time have been consumed; and it should be noted that this third would represent the most available, the most easily-worked, and the most valuable of our coal. By this computation our coal would be exhausted about the year 1978, or in ninety years from the present time. In 1978 the calculated output would be 48,100,000 tons; but it would be misleading to imply that this enormous output will come suddenly to an absolute stop. It is quite obvious that at some point in the interval the output must reach a maximum, after which, by the operation of certain causes which must act on the output, the production will gradually diminish till the inevitable point of exhaustion is reached.

Assuming that the low rate of increase indicated above continues in the immediate future, the choicest and most available half of our coal would be consumed in 1964, the total estimated output at that date amounting to 502,775,000 tons. In that year the output would be 24,275,000 tons; and, assuming that at this point the maximum output is reached, and that a geometrical decrease backwards commences from that year, the date of exhaustion would be somewhere about the year 2053—that is, 165 years from the present time.

It should always be remembered that the total quantity of available coal in New Zealand is only equal to about five years' output of Great Britain, and is, in fact, contained twice over in the coalfields of the county of Cumberland alone. It is only when our annual output is placed against the total amount that our stores of coal can be spoken of as vast or extensive.

Steam is the great motive-power of the period; consequently the growth and development of our manufactures and shipping must always be relative to, and in many cases caused by, the production of coal. As, therefore, the inevitable must come, whether in ninety years or 165 years, it is necessary that our coal-deposits should be worked with economy and with a regard to the future as well as the present prospects of this important industry.

Art. XXXVIII.—*The Alluvial Deposits of Otago.*

By L. O. Beal, sen.

[*Read before the Otago Institute, 11th July, 1888.*]

In April, 1870, in the young days of this Institute, I had the honour of addressing the members on the subject of the "Alluvial Deposits of our Goldfields;"* also since then, some fourteen years back, without, however, writing a paper for publication, on the same subject, especially in reference to a change in the earth's polarity; and I now, with your permission, beg to supplement my remarks.

The "glacial epoch" is so thoroughly recognised as having occurred in the earth's history that I need here but mention it as a fact. It has been alluded to by many authorities. The explanation of the existence of this period I assume to be that the polarity of the earth has, in the course of an extremely long period, changed—*i.e.*, the east and west of to-day were once at north and south, thus allowing the earth's surface to have become gradually and entirely under the influence of the polar climate, and equally so under the influence of the equatorial climate, thus accounting for the remains of tropical flora and short-haired animals near the north pole—the presence of the body of the megatherium mentioned by Lieutenant Nordenskjöld in the neighbourhood of the mouths of the rivers Obi and Yennisei, and the large accumulations of ivory tusks at Nova Zembla, being notable illustrations; whilst the appearance of ice on the equator, as noticed by Professor Agassiz, in describing his holiday trip up the Amazon River; and in our own home of New Zealand,—and, though I am not conversant with Australian writings, I feel sure the same features have been observed and described there,—amply bear out the same theory. The subject is well described by Mr. J. T. Campbell in his book "Frost and Fire," as applicable also to the British Isles.

Viewing the physical construction of the earth, as shown in any map, we find its circumference at the poles and the equator to differ by something like twenty-nine miles—a fact of such great moment that we can scarcely embrace its importance, as a very little of so great a difference would account for the altitude necessary to bring about the climatic changes we are considering. The subject of the action of ice at the present day may be read of in any travellers' books, such as Ross's "Antarctic Expedition," Lord Dufferin's "Letters from High Latitudes," E. Whymper's "Scrambles in the Alps," and many others. The enormous time such events would occupy,

* "Trans. N.Z. Inst.," vol. iii., p. 270.

and the large amount of *débris* carried by the ice in this glacial epoch, will well account for the wearing-power we see in the ranges of mountains, in the vast accumulations and the different varieties of rocks and soils that fill our valleys, and in the equally extensive appearance of flowing water that has so fully sorted them during their deposition.

To-day we observe in valleys running east and west very strong evidence of their shady and sunny sides in the difference in the growth of vegetable life; and in the glacial epoch this difference between the shady and sunny sides I imagine to be equally observable. The shady side, facing the south, would be the last home of the glaciers, and thus account for the greater quantity of deposit which we call the terraces of to-day; whilst the sunny side, facing the north, being more under the influence of water caused by the melting snow, has been scoured out, and has thus prevented the *débris* being of equal height on both sides of such valleys. Every valley thus tells its own geological story, a large one like the Clutha or Molyneux Valley having, of course, more to tell us than its smaller companions.

When considering this subject we must bear well in mind the difference between the very gradual melting of snow and the more powerful water-scouring of our present rainfall—sometimes light, sometimes heavy, especially during tropical and thunder storms. The persistent, steady melting of the snow, no matter of what magnitude the snowfalls might be, would give us those regular or almost regular and light bands which we see in the banks of the Molyneux River, my lowest point of observation, and in the photograph which I show of the celebrated Mount Burster Claim, in the Kyeburn Ranges, some 4,000ft. above the level of the sea, which forms my highest point of observation. The deposits at the Blue Spur, Tuapeka, and other large sluicing-claims at lower elevations, tell the same story. The consideration of this subject is necessarily very absorbing to us as dwellers in this land of golden deposits. It indicates and points to the evidence of old channels of rivers, the objects of search to the miner and of possession to the speculator and capitalist; and it will not be denied that wherever the bed-rock in the Silurian formation has been reached large deposits of the precious metal have been found, as at Gabriel's Gully, Tuapeka, Butcher, and Conroy Gullies, adjoining the Manuherikia River, in the Molyneux Valley. Occasionally, also, rich deposits have been found when sinking in the terrace-formation, as at Ross Flat, on the west coast, and in the Cardrona Valley. These two latter may be pictured to our minds by considering the river-features of to-day—say, for instance, in the lower part of the Shag Valley, where the Shag River

closely resembles a letter S; and it will be admitted that, could we take up a slice sufficiently thick, and thus bare to our view this valley at an earlier time, before it had been so much filled up as to-day, we should find this river equally meandering, only that it would have to be described by opposite curves to the letter S of to-day; and in the intermediate depths the same large waterflow would be observable, and thus explain to us the meaning of the following extract from the *Otago Daily Times's* (27th April) mining intelligence from the Arrow: "The gold was found in the stuff taken out in the operations of boring, and several layers of wash were passed through, all showing more or less gold. The bore-hole is now down upwards of 100ft. without striking the bed-rock. The prospects of the field are better than ever before." The bands of wash-dirt, of course, indicate to us the larger water-sorting of the then course of the river.

I must apologize for the brevity and incompleteness of this paper, as I have had no opportunity for travelling for some few years, and beg you will find an excuse for me; but if I have succeeded in drawing attention to this subject, that others who dwell in districts more favourable for observation than Dunedin may profit by it, I shall be content. I need hardly say that all valleys are filled up in the way indicated by the foregoing remarks.

Of the photographs I now exhibit No. 1 is of the Mount Burster Claim, showing the bands I have alluded to; No. 2 is of the Müller Glacier, and brings under our notice the *débris* it is carrying, also at its foot exhibits the water flowing. The glacier is melting on its surface exposed to the rays of the sun, and thus causes the stones with which it is charged to become more apparent than its normal condition would be when nearer the pole.

Art. XXXIX.—*Note on Rock collected by the Rev. W. S. Green from near the Summit of Mount Cook.*

By Professor T. G. Bonney, F.R.S.

Communicated by Professor F. W. Hutton.

[*Read before the Wellington Philosophical Society, 9th January, 1889.*]

Under the microscope this rock is found to be composed of —(1) angular fragments of rather clear quartz, commonly less than 0·1in. in diameter, but occasionally as large as 0·15in.: (2) rather earthy-looking fragments of about the same size, which on examination with a high power are found to be crowded with filmy microliths, often faintly tinged with green, giving

bright colours with the crossed nicols; these about equal the quartz in quantity, sometimes the one, sometimes the other predominating; very probably they are fragments of a decomposed felspar, but some may be bits of an argillite: (3) fragments of well-preserved felspar: (4) some fragments of a rather fibrous brown dichroic mineral, probably biotite: (5) two or three fragments of a filmy green mineral, probably an altered form of (4): (6) a white mica. The microscopic aspect of the rock would suggest that it was a quartzite; but the microscope shows no marked deposition of secondary quartz, or any indication of *metamorphism*, so that it must be named an indurated, rather felspathic grit. It is not likely to be an Archæan rock, but has probably derived its materials from rocks of that age, being itself very possibly Palæozoic. There is no very definite indication of either a laminated or a cleaved structure.

ART. XL.—*On a Striated Rock-surface from Boatman's, near Reefton.*

By G. J. BINNS, F.G.S.

[*Read before the Otago Institute, 11th September, 1888.*]

PLATE XXV.

THERE is no source of geological action more frequently appealed to for elucidation of problems in dynamical geology than ice; and the various traces of its former presence, in the form of striated boulders and rock-surfaces, *roches moutonnées* and *blocs perchés*, are familiar to all, if not from actual experience, at least from the text-books.

It is very necessary, in ascribing great geological results to this agency, to be certain that the evidence upon which we base our calculations—frequently erecting a vast superstructure of hypothesis upon a very small foundation of evidence—is indisputably true.

As an example of what might, were its origin not known, have led to misconception and possible error, I beg to bring before this Institute an example of a striated rock-surface, in the grooving of which ice-action had no part. (See Plate XXV.) The fragment of rock forming the subject of this paper was removed by me, on the 4th of May, 1888, from the surface of a large mass of *débris* resulting from a landslip which occurred at Boatman's, near Reefton, during the preceding March. It consists of a piece of indurated arenaceous clay, containing some mica and indistinct carbonaceous impressions, and its

geological position is in the Cretaceo-tertiary series of the New Zealand Geological Survey. The surface of the specimen, which is one of innumerable equally well-marked samples which might have been chosen, is scored in more than one direction by grooves or striæ, which vary much in depth, the maximum being about $\frac{1}{16}$in.; and were it not that some of these are curved they would present no features distinct from true glacial striæ.

The slip occurred on a surface of the coal-measures dipping at 25°, and was caused by the accumulation of surface-water in a deposit of soil and vegetable growth, the cohesion of which had been destroyed by fires. After proceeding for some distance the direction of the moving mass was changed to about 40° from the straight line by an outstanding mass of quartzose grit, and at this point the whole body plunged over a vertical cliff about 20ft. in height, forming a veritable cascade of mud, and stones, and tree-roots. In the lower portion the angle of slope was reduced to 10°, and at this point a cottage was carried away and destroyed, unfortunately not without loss of life, for an infant member of the family was left behind in the confusion, and the mother perished in a heroic but unsuccessful effort to save her child.

The surface bared in the upper portion of the slip is fireclay, rendered very slippery by the presence of water, while the part which came away consists, below the soil, of about 8ft. of fireclay and quartz grit, the hard fragments of the latter causing the striation of the remaining rock, which at the time of my visit was covered with numbers of well-defined grooves.

Art. XLI.—*On the Neighbourhood of Te Aoroa, Northern Wairoa.*

By John Harding, of Mount Vernon.

[*Read before the Hawke's Bay Philosophical Institute, 13th Aug., 1888.*]

Te Aoroa is situated on the west bank of the Northern Wairoa, between Aratapu and Dargaville. This, together with a long stretch of country to its north and south, is classed as "drift" on our geological map. This would apply to the high lands, but about one-fourth is rich alluvial flat and swamp, the hills soft sandstone, varying in colour from snow-white to black. The coast-hills differ much from those farther inland, the latter having a large quantity of bog-iron mixed with the surface-soil, in many parts rendering it impervious to water, and so almost useless for agriculture or grazing. All this hill-

land was once grand kauri forest: this is proved by the quantity of kauri-gum found on it. It has been worked as a gum-field—sometimes as many as two hundred men digging on it at one time—for the last thirty years (so I have been told by old residents), and yet it still yields a good quantity.

The cliffs on the coast show the same drift-sand nature down to sea-level. They also show that many great changes have taken place, and that the late kauri forest was not the first, for in the cliffs are several beds of good lignite, divided from each other by thick beds of drift-sand. This lignite contains many kauri-trees and fossil gum (ambrit).

The higher hills all have remains of old pas on the tops, and you can learn the history of them from the Maoris; but since my sons have had the place the remains of a very large old pa have come to light, of which the oldest natives say they have never heard. There are indications that the whole has been covered with forest, though not kauri, for kauri does not appear to have grown on the present coast-hills since the days of that pa.

When I bought the property this part was covered with a dense growth of fern, tutu, and scrub. This was burnt off, exposing the surface to the west winds, which removed the surface vegetable soil, then the sand, thus exposing bit by bit the ground-plan of a pa. It is on a large flat, and the process of uncovering is still going on. After a heavy gale my sons often find stone axes and pieces of stone, a kind of flint; but I have not seen any remains of wooden articles.

At one place, known as Mount Wesley (an old Wesleyan mission-station), the sandstone hills reach from the coast to the bank of the Wairoa, and one seam of the lignite crops out and forms a small reef in the river near the bank.

One strange feature of the country is the presence of a layer of blue clay or mud in a liquid state at varying depths. This mud was first found by my son in sinking a hole for a strainer-post. He hit the seam, and it ran over the top of the hole; and, though that is some nine years ago, it still runs at times, and has formed a quagmire about the place in which he has had many sheep smothered till he fenced it round. Recently a country road was cut through the hill at Mount Wesley. As the work proceeded one of my sons told the contractor that he was getting very near this mud, and cautioned him to alter his line slightly. The contractor laughed, and asked where mud was to come from on a hill; but a few more strokes of the pick hit the seam, and out flowed the mud, and the place had to be sheet-piled, and that only partly stopped the outflow. It was running along the side of the road when I was there a few weeks since. This mud or clay is just like what the early Wellington settlers used to call earthquake

mud or clay, because it always ran out of cracks and holes in the ground at the time of an earthquake.

About the centre of the property there are a number of caves. The only known way of entering is to be lowered down by a rope. When inside there is a slight glimmer of light from somewhere; but, as Paddy said when lost in a large building, you cannot find the entrance out. I think these caves were formed as follows: The entrance-hole is in the centre of a slight hollow. Here, of course, the rain-water would accumulate, and percolate through the sandstone to the layer of mud, thence out at the bottom of the inland cliffs to the swamp below, taking the mud and soft sandstone with it. Possibly when the swamps are fully drained entrance to the caves may be found at the foot of the cliffs.

I can see no difference in the stone axes and adzes found at the exposed pa. However, I can only think that its origin must date back to a time far beyond what we give for the arrival of the Maoris—possibly to a previous race of people. This view is strengthened by the fact that in draining parts of the large swamp to which I have referred my sons came upon ancient draining-works, showing that these swamps had been drained ages ago, at the cost of much labour and skill. Large ditches have been dug, running from one mile to one and a half miles long, and as straight as an arrow, from the river back to the foot of the hills.

Now, so far as my experience goes, the Maoris rather prefer to make a swamp than drain one. They will build eel-pas across streams, thus damming back the water, flood the surrounding country, and so create a swamp. A large proportion of the swamps at the Thames and the Waikato are said to have been made by eel-pas, and there is evidence that some of the Te Aoroa swamp has been thus made; so I think the old pa and the old drainage-works are the work of a race which lived here before the Maoris.

Art. XLII.—*Notes on the Geology of Tongariro and the Taupo District.*

By Professor A. P. W. Thomas, M.A., F.L.S., F.G.S.

[*Read before the Auckland Institute, 30th July, 1888.*]

Plates XXVI.–XXXII.

We owe our first accurate knowledge of the geology of the Taupo volcanic zone to von Hochstetter. Although he spent a comparatively short time in the district, his great geological insight

enabled him to give a remarkably good account of some of its general features, and especially of its wonderful development of geysers and hot springs. He was, however, unable to ascend any of the great volcanic cones in the district, and he states that, although he gazed longingly at the massive outlines of Tongariro and Ruapehu, far to the south of the limit reached by him, neither time nor opportunity offered itself. Moreover, the Maoris had declared the mountain *tapu*, and would have strenuously opposed any projected ascent.

For many years little was added to our knowledge of the geology of the district, and it was not until after the unlooked-for eruption of Tarawera had recalled attention to the subject in so startling and emphatic a manner that further contributions were published. Mr. Cussen, in a paper read before this Institute last year, gave a general description of Lake Taupo and the country to the west, whilst in the reports on the Tarawera eruption by Mr. Percy Smith and the writer respectively there will be found additional information concerning the Taupo volcanic zone and the cones to the south. Mr. Park and Mr. L. Cussen have also published accounts of the ascent of Ruapehu.

Nevertheless the detailed description of the geology of the great cones to the south of the lake has not yet been given, and there is many a problem connected with the geology of the district which has scarcely been attacked. The present contribution to the subject is founded on observations made during various visits to the Taupo district, more particularly in January, 1888, when the writer passed a few days encamped at the foot of Tongariro. His time was chiefly spent in the examination of Tongariro; and a contemplated visit to Ruapehu was delayed by other work undertaken for the Government. He trusts, however, to have an early opportunity of making a more extensive examination of other parts of this locality.

Perhaps the greatest interest centres round the Ruapehu-Tongariro chain of volcanic mountains, for we have here no fewer than three cones — viz., Ruapehu, Ngauruhoe, and Tongariro—which have shown signs of greater or less volcanic activity within recent years. This chain (see Plate XXVI.), which has a length of fifteen or sixteen miles in a direction 26° east of north, rises up from the centre of a plateau nearly 2,000ft. above the sea-level. The plateau is bounded on the east by the Kaimanawa Range, composed of the ancient Maitai (Carboniferous) slates and sandstones, rising to a height of 5,225ft. in the Umukarikari Mountain. The Ruapehu-Tongariro line is nearly parallel to this range at a distance of some ten miles. To the west the

plateau is bounded by a range of mountains which passes northwards into the main range west of Taupo Lake. On the north the plateau is separated from Lake Taupo by the volcanic mountains Pihanga and Kakaramea (4,266ft.) and the ridge of volcanic rock which connects them. The Waikato River (called in this part of its course by the natives the Tongariro) rises in Ruapehu and flows northwards towards Lake Taupo, receiving many tributaries from the eastern side of the Ruapehu–Tongariro chain and from the western slopes of the Kaimanawa Range, and passes to the east of Pihanga as a broad, shallow, swiftly-flowing river. It enters Lake Taupo at the southern end, about two miles from Tokaanu, and has formed a very considerable delta, composed of the *débris* of volcanic rock from the western sides of the various cones, and of the slate found in the Kaimanawas. These two materials, of such different origin, are present in approximately equal proportions.

Ruapehu is the highest of the great volcanic cones, rising to 8,878ft. Many observers seem to have suspected that the vapour hanging about the summit on certain occasions, even in fine dry weather, was due to volcanic energy in the mountain; but it was not till April, 1886, when Mr. Cussen ascended the mountain, that the matter was placed beyond doubt.* He found a lake of warm and steaming water occupying a basin about 300ft. below the two chief peaks of the mountain. No steam was rising from the mountain during my visit to the district in 1888; but I was informed that it had been seen a few weeks earlier.

The summits of Ruapehu and Ngauruhoe are distant from one another a little more than eight miles, but they are connected by a ridge of volcanic rock, on top of which lie two lakes known by the name of Nga Puna-a-tama. These lakes appear to lie in craters which mark the sites of former centres of activity along the volcanic line.

Tongariro lies close to and abutting on the north-east side of Ngauruhoe, and the latter mountain is often miscalled Tongariro. The two mountains, though so close together, are sufficiently distinct in form and position to call for separate recognition.

Ngauruhoe.—Ngauruhoe is considerably higher than Tongariro. It forms a beautifully regular steep-sided cone, which rises to the height of 7,481ft. The height is greatest to the east, so that viewed from the north the mountain has an obliquely-truncated appearance. From the crater on the top steam constantly issues in considerable volumes, and, driven

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* "Thermal Activity in the Ruapehu Crater," by L. Cussen, "Trans. N.Z. Inst.," vol. xix., p. 374.

before the wind, forms a long train to leeward. To the north the crater-margin is partly broken down, and the surface of the ground here is rotten and treacherous from the action of the acid vapours. The hydrochloric acid in the vapours reacting on the iron oxides in the scoriæ forms considerable quantities of perchloride of iron, which stains the ground brilliant shades of yellow and orange, distinctly visible even from the top of Tongariro.

The sides of the cone are for the most part smooth and regular, and are formed of scoriæ and fine ashes, but here and there rugged projecting rocks mark the course of lava-streams. One of these, which descends as far as the south crater on Tongariro, ends there in a steep front of lava, with black scoriaceous surface, about 30ft. in height. This stream is said to be that which flowed from the crater during the eruption of Ngauruhoe in 1869.

It has been reported that Ngauruhoe has shown great signs of activity recently. I am indebted to Mr. Howard Jackson, the engineer in charge of the road-makers near Tongariro, for notes and sketches (see Plate XXVII.) bearing on the subject. Mr. Jackson has been in the district almost continuously for more than twelve months, within full view of the mountain. He states that on the whole the mountain has shown, if anything, rather less activity than usual, but that during bad weather which occurred in April or May, 1888, a gap was formed by the breaking-in of a portion of the crater-wall to the east. As seen either from the east or west, there is now a deep V-shaped notch which must have the depth of about 200ft. (see Plate XXVII., figs. 5 and 6). A comparison of the present outline of the cone with the drawings made by Hochstetter in April, 1859 (figs. 1 and 2) shows that a large amount of change has taken place since that date.

Although Ngauruhoe rises so high above the sea-level, the snow does not lodge long on the cone: the ground in many places is warm, and the internal heat passing slowly outwards, together with the steam rising from the crater, is sufficient to thaw the snow. The steam which rises so constantly from Ngauruhoe comes chiefly from a smaller, deeper crater, with dark and steep sides, lying within the circle of the principal one. From this crater ashes and fragments of scoriæ are frequently ejected.

Tongariro.—Tongariro, the third of the great mountains, is, strictly speaking, composed of a number of distinct cones built up around so many separate points of eruption. These cones, however, are so close together that the mountain forms at its base a single mass. Viewed from a distance the mountain has a broad, flat-topped appearance, but as it is

approached the separate cones of which it is formed at the top become more distinct. (See Plate XXVIII.) The lower slopes of the mountain are composed of lava-streams, which stretch as far as Rotoaira, the lake to the north; indeed, the formation of the lake appears to be due to the blocking of the drainage-channel by a lava-stream. These lower slopes are covered with tussock-grass, which affords a certain amount of support to animal life, so that the slopes of the mountain have been employed as a sheep-run. On the north side there is a large area of forest. Amongst the tussock-grass small herbaceous plants with bright-coloured blossoms grow in far greater abundance than is usually seen in New Zealand except in alpine districts. The summit of the mountain is all but devoid of vegetation.

That portion of Tongariro which lies to the east is often termed by the natives Te Mari, whilst the part to the west is Tongariro proper. The top of the mountain is marked by seven large craters, as well as some smaller ones. The distribution of these will be best gathered from the accompanying sketch-map (see Plate XXIX.), which will, I believe, be found sufficiently accurate for our present purposes.

The ascent of the mountain is most easily accomplished by way of Ketetahi, a hollow at the height of 4,900ft. on the side of the cone which forms the north-west angle of Tongariro. Ketetahi is not, properly speaking, a crater, though explosions of steam seem to have assisted in the excavation of the hollow: it resembles rather the enlarged head of a gully. There are many hot springs and a powerful escape of steam here, whilst the overflow of the water forms a warm stream. The volume of steam rising from Ketetahi is usually very considerable—so copious, indeed, as to render the spot visible for a distance of fifty miles.

Two other places on Tongariro are marked by the escape of steam, which betrays the volcanic forces dormant within the mountain. One of these is on the northern slope of Te Mari, the other is in the Red Crater; but neither shows so much activity as Ketetahi. Above Ketetahi the slope of the cone becomes steeper. It is formed of lava having a comparatively smooth surface of step-like formation, which greatly facilitates the ascent.

On reaching the summit of the cone a remarkable sight presents itself. The top is formed by a circular area half a mile in diameter, which at first strikes one as being perfectly flat. Closer examination, however, shows minor undulations, the surface of the wind-swept ground being strewn with fine sand-like volcanic ashes and lapilli. To the north, and, again, on the opposite side, towards the south, a cliff of lava rising perhaps to 100ft. above the crater-bottom forms the boundary

of the area, whilst elsewhere around the margin the ground dips down abruptly to the steep outer slope of the cone (see Plate XXX). The two lengths of cliff and a few other rocks in the same circle evidently mark the former rim of a crater, which at a subsequent period was filled up by lava, which overflowed the brim and formed streams on the rocky sides of the cone. From its position we may distinguish this filled-up crater as the North Crater of Tongariro. On the west side, and just within its margin, it contains a smaller funnel-like crater of considerable depth. The cliff to the south is chiefly formed of thick horizontal beds of dark lava. At the western angle of the cliff the smooth and slightly-weathered surfaces of the joints in the lava show a remarkable streaky structure, visible from a great distance. This flow-structure, which bears testimony to the unequal movements in the lava at the time of its consolidation, is due to the irregular alternation of a light- and dark-grey material in the ground-mass of the lava. Near this spot the surface of the ground is covered with a layer of an exceedingly light pumice of acid composition, differing greatly from the other rocks found on the mountain. The largest of the fragments was 14in. in its longest diameter. Reference to this and other rocks on Tongariro will be found further on.

Between this North Crater and the rest of the Tongariro system is a dip of 200ft. or 300ft., by which it is marked off from the rest of the mountain-top. To the south, and stretching as far as the slope of Ngauruhoe, is another cone, marked by a very large crater, over half a mile in length. This crater, which we may suitably distinguish as the South Crater, is of a much elongated form, and it is worthy of note that its long axis coincides in direction with the Tongariro–Ruapehu line.

Its walls are very steep, and in many places precipitous. They are highest at the end towards the North Crater, and gradually diminish in height in the direction of Ngauruhoe. The highest part of the crater-wall, which is also the highest point on Tongariro, lies on the western side, and is about 6,450ft. above the sea-level. The crater-flow lies over 800ft. below this point. At times the bottom of the crater must be covered in part by a shallow lake, which discharges at the end towards Ngauruhoe. The water will pass down the watercourse between the latter mountain and Tongariro, and form the beginning of the Mangatepopo Stream, a tributary of the Wanganui River.

Travelling along the ridge which forms the eastern boundary of the South Crater, we pass two large craters on the right. The first of these has high precipitous sides towards the west, whilst to the east its wall is wanting,

and the eye stretches over vast fields of rugged hummocky lava.

The second, or Red Crater, lies further to the north, and is interesting as showing the signs of recent activity. The crater has very steep sides, so that from the west at least it is not possible to descend into it. The upper part of the crater is formed by a great thickness of beds of dark blood-red scoriæ having an extremely close resemblance to the layers of scoriæ of the Tarawera eruption which lie piled up on the borders of the fissure on the Tarawera Mountain. It is said that steam can be frequently seen issuing from this crater; but none was visible on the occasion of my visit. Around the margin of this crater blocks of a dark heavy lava, having the appearance of a basalt, and more basic than the usual lavas of the mountain, are to be found. Across the floor of the crater is a small lava-stream.

To the north of the Red Crater, on the part of the mountain called Te Mari, is an old crater of considerable size. Lying to the east of this, and separated by a comparatively low ridge of rock, is another crater, containing a lake of the most beautiful blue water (see Plate XXXI.); whilst on a ridge between this and the Red Crater are two much smaller lakelets, one of which from its colour has been called Rotopounamu (Greenstone Lake).

On the north-eastern slope of Te Mari is yet another crater of considerable size, and close to this, as already mentioned, there is a large but intermittent escape of steam.

Lake Taupo.—It is not my intention to enter here into a detailed description of Lake Taupo and the surrounding country, but merely to mention such points as we shall have occasion to refer to hereafter or as have not been previously described. The lake has an area of nearly 242 square miles; it is 24¾ miles in length and 16¼ miles in extreme width, and has a shape which has a general resemblance to that of the continent of Africa. In many places the lake is bounded by steep cliffs of lava and associated tuffs. That the lake formerly stood at a higher level is clearly shown by the terraces around it, which are continued up some of the small valleys leading into the lake. One terrace stands at a height of 100ft. above the present water-level of the lake. The accompanying plate (Plate XXXII.) shows this terrace at the south end of the lake, about three miles from Tokaanu, looking in a northerly direction. Another well-marked terrace lies at the height of 300ft. to 400ft. above the lake.

The lavas at the north, east, and part of the western sides are rhyolites; at the south end they are chiefly augite-andesites. The pumice-deposits which form so remarkable a feature of the Taupo district are found to a greater or less

extent all round the lake; they are thickest, however, near the northern end, reaching the thickness of 300ft. in one of the cliffs. Throughout the district, indeed, the pumice is widely spread over the surface of the ground, especially to the east, north-east, and north of the lake. It is found even on the summits of the highest mountains—here, however, merely as a sprinkling, whilst at the bases of the hills and in the valleys it may reach the depth of hundreds of feet. The manner in which the river-valleys have been filled up with pumice, out of which the water has excavated terraces, is sufficient evidence of the influence of running water in distributing the pumice. There are, however, many facts which show that much of the pumice has travelled through the air and fallen in showers in its present position.

Popular belief ascribes this pumice to the great volcanic mountains Ruapehu, Ngauruhoe, and Tongariro, which lie to the south of the lake, the showers of pumice being supposed to have been brought by the prevailing south-west winds. Any one who will examine the distribution of the ash from the Tarawera eruption* will see that the explanation has a *primâ facie* probability, for in that case the ash was spread out in just such a manner. But the examination of the neighbourhood of Tongariro shows that such an explanation is not applicable to the distribution of the pumice in the Taupo district. The pumice is less abundant in the neighbourhood of the great mountains than elsewhere in the district, and, as will be shown further on, the rocks of Tongariro belong to a different group. The pumice around Lake Taupo contains considerable quantities of rhyolite-fragments other than pumice, especially of the perfectly-laminated variety which has been termed lithoidite. Near Ouaha, on the east side of the lake, I found angular blocks of lithoidite 3ft. and more in diameter, and weighing two tons or more, imbedded in the pumice-deposits. It is obvious that blocks of this size cannot have travelled any great distance, whether by the agency of water or the force of volcanic explosions, but must have been derived from some source near at hand. The only localities near Taupo that I am acquainted with where this variety of rock is found *in situ* in lava-streams are at Motutaiko, the island in the lake, and Hamaria, three or four miles distant, on the shores of the lake. We might perhaps not unnaturally look to Tauhara, the volcanic cone at the north end of the lake, as a source of part of the pumice. This mountain has the height of 3,603ft., and the country at its base on both

* A map showing the distribution and depth of the ashes from the Tarawera eruption will be found in the "Report of the Eruption of Tarawera and Rotomahana," by the writer.

sides of the Waikato River is remarkable for its vast number of hot geysers, &c. The mountain has a large crater on top (Hochstetter stated that there was no crater), and its upper part is thickly covered with forest. I found on top of Tauhara a sprinkling of pumice, with small fragments of lithoidite quite different from the rock of which the mountain consists. The lavas, as far as I observed, are all of acid composition, but contain a rather large amount of hornblende, a mineral not found, so far as I have seen, in the pumice-deposits.

Hochstetter supposed that the formation of Lake Taupo was due to subsidence of its area, a supposition which is strengthened by the abrupt, precipitous character of part of its shores and the fairly uniform depth of its waters. A more popular theory supposes Lake Taupo to have been an immense crater; but evidence of this is wanting, though it is quite conceivable that the sunken area was marked by vents from which perhaps a portion of the pumice which covers the district was derived.

The Waikato leaves Lake Taupo at the north-east end of the lake, and for the first part of its course flows to the north-east in a gorge through rhyolitic tuffs. Three miles from the lake its course is broken by the Huka Rapids and Fall. The tuffs here are locally hardened by the deposit of a siliceous cement from the hot springs, which have attained a considerable development at one time, and are indeed still represented by one or two warm streams close to and above the rapids. The river on reaching the harder rock becomes suddenly narrowed to less than a quarter of its usual breadth, and, confined to a narrow channel with vertical sides and sloping bottom, rushes through it with an arrowy swiftness which the eye can scarcely follow, until at length it plunges downwards some 30ft. into a wide basin of water eaten out of softer rocks. Some of the finer pumiceous sands here contain such an abundant siliceous cement of siliceous sinter that to the naked eye they have the half-glassy appearance of a pitchstone, and have, indeed, been described as lavas.

A few miles further on, however, the Waikato crosses a series of lava-streams, and the harder rocks have led to the formation of the beautiful rapids known as the Aratiatia Falls. The lavas are rhyolites, chiefly of a glassy character, spherulitic obsidians being well developed.

Volcanic Fissures in the Taupo Zone.—We have already seen that the Tongariro–Ruapehu group of volcanoes are arranged in a straight line, which doubtless represents a fissure in the earth's crust by which the molten rocks have forced their way to the surface. It affords, indeed, a remarkable instance of a number of volcanic vents arranged close together on the same fissure. We have the huge mass

of Ruapehu at one end, then the two crater-lakes of Nga Puna-a-tama, the lofty active cone of Ngauruhoe, and then the direct line is continued by the South and North Craters on Tongariro.

If, with a slight deviation in direction, the line be continued to White Island, we find that it passes through a large number of points remarkable for their volcanic activity, including Tarawera and Rotomahana. This line may therefore be justly looked upon as the main line of volcanic activity in the Taupo volcanic zone.

Nor is this the only instance of great fissures connected with the volcanic activity of the district. In the northern part of the Taupo zone we have two lines marked by hot springs as well as by dislocation of the rocks. These lines are parallel to the main line, and probably correspond to great fissures in the rocks. The first of these lines, seven miles from the main line, stretches from Orakeikorako along the east face of the Paeroa Range to Rotoehu, a distance of thirty-seven miles. The second line is eight miles further to the west, and stretches from the hot springs on the Waipapa Creek, near the Waikato, through Rotorua to Rotoiti.

We may reasonably ask whether these lines of fissure are represented further to the south. If they are produced in that direction they will be found to coincide generally with the lie of the shores of Lake Taupo. The main line will correspond with the eastern shores; whilst the Orakeikorako line will correspond with the western shore of the lake from Waihi to the bold and precipitous headland of Karangahape—*i.e.*, south of Western Bay; and the Rotorua line will correspond with the western shores of the broad arm of the lake known as Western Bay.

It will be noticed, however, that the coincidence is not exact, the lines showing a tendency to converge as we approach the south, the point of convergence being Ruapehu. There can be no doubt that Ruapehu marks the position of an important centre with reference to the broader structural features of the North Island. It is here, or near here, that the line of elevation marked by the northern peninsula joins the main axis or backbone of both islands. The line of the western coast of the peninsula north of Auckland, if produced, will be found to pass approximately through Ruapehu. In other words, the structural axes and dislocations of the country radiate from near Ruapehu, and the manifestation of volcanic forces here is determined by its position with reference to the great flexures of the earth's crust.

The examination of these radiating lines cannot fail to remind the geological reader of the system of cracks obtained by Daubrée during experiments on the fractures produced in

homogeneous substances, such as ice, by torsion.* Such systems of fractures may also be readily obtained in glass. Daubrée obtained systems of fractures crossing one another at angles approaching a right angle. In each system some of the fractures were arranged in a radiating or fan-shaped manner, others were parallel to each other. Great caution, of course, is needful in applying such results to the explanation of natural dislocations, for it is uncertain how far we are justified in supposing the earth's crust would behave as a homogeneous mass, and the conditions of the experiment are no doubt very different. Still, the resemblance of the arrangement of these natural dislocations to that of the artificial fractures is sufficiently close to lend interest to the comparison.

Many instances of transverse dislocations might be cited in the Taupo zone. The line of volcanic mountains at the south end of Lake Taupo may be due to such a fracture. We have here the two mountains Kakaramea (4,266ft.) and Pihanga, of about the same height. They are connected by a high ridge of volcanic rock, and the long axis of the group lies at right angles to the line of the Ruapehu–Tongariro fissure. Pihanga has a crater showing to the north, and Kakaramea is said to have traces of a crater. The rocks of which they are composed are generally similar to those of Tongariro. Where the slopes of these mountains come down to the south shore of Lake Taupo we find the hot springs and geysers of Tokaanu, as well as various springs at intervals as far as Waihi.

Rocks of Tongariro.—Specimens of rocks from Ngauruhoe and Ruapehu were collected by Mr. Cussen in 1887, and were described by me in the "Transactions" of the Institute.† Since then I have had the opportunity of making very extensive collections of rocks on Tongariro and in its neighbourhood, and am able to add to what was then written. I am indebted also to the great kindness of Mr. J. A. Pond, Colonial Analyst, for a valuable and extensive series of analyses of rocks from Tongariro, Ngauruhoe, and Lake Taupo. These furnish an important and welcome supplement to the results obtained by microscopical examination.

Hochstetter has stated that all the rocks collected by him in the Taupo volcanic zone belonged to the family of acid volcanic rocks known as rhyolites. In the paper referred to it was shown that the intermediate (or slightly basic) group of lavas known as the augite-andesites were largely represented in the district. This result is amply confirmed by Mr. Pond's

* Daubrée, "Etudes Synthétiques de Géologie Expérimentales," tome i., p. 307.

† "Trans. N.Z. Inst.," vol. xx., p. 306.

analyses. My own collections show that the typical rocks of Tongariro are augite-andesites, though more basic rocks, which may be regarded as members of the basalt group, are also represented. Perhaps the commonest variety of these augite-andesites is one which is found, amongst other places, on the slope of the North Crater of Tongariro, where it forms the lava-streams above Papakai. Similar lavas descend as far as the shores of Rotoaira. The rock is a porphyritic one, of medium grain and dark colour, showing when quite fresh a slight resinous lustre. The porphyritic crystals are numerous, but none of them reach a length of over 3mm., and they are usually much smaller. Examination with the microscope shows that the porphyritic crystals consist of felspar and augite in about equal proportions and in well-formed crystals; there are a few smaller magnetites in irregular crystals. The felspars are almost all striated, and many of them are crowded with inclusions of glass, which is sometimes brownish and pure, at other times is colourless, but containing globulites and dark granules. The felspars also contain inclusions of augite and apatite. The augites are in eight-sided prisms; in thin section they are yellowish and only feebly pleochroic, the range of tints being from greenish-yellow to brownish-yellow. A few of the largest augites are completely honeycombed by groundmass. The groundmass is hyalopilitic—*i.e.*, it consists of a felt of crystallites united by rather abundant colourless glass. It contains a considerable number of black granules of magnetite. The crystallites include great numbers of long, slender, non-polarising longulites, and very few of these incipient forms are sufficiently developed to polarise. Olivine is altogether wanting in the rock. The augite and felspar not unfrequently occur in nests composed of great numbers of crystals, which only show their proper form on the exterior of the groups. The analysis of this rock is shown as No. 1 in the following table. Its specific gravity is 2·76:—

TABLE of ANALYSES of VOLCANIC ROCKS by J. A. Pond, Colonial Analyst, Auckland.

—	Rotoaira.	Otouku	Red Crater.	Ash.	Ngauruhoe.	North Crater.	Motutaiko.	Hamaria.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Silica ..	61·25	60·15	52·1	57·9	57·0	75·25	78·9	78·4
Iron peroxide and alumina	30·55	29·55	29·45	31·95	32·55	17·2	19·15	17·2
Lime	6·35	7·42	9·49	7·5	6·98	1·75	1·62	1·22
Magnesia ..	1·89	1·5	8·15	1·05	0·81	0·15	0·25	0·05

Nos. 1–4 are from Tongariro: No. 1, an augite-andesite from the lava-stream which reaches Rotoaira; No. 2, ditto from Otouku; No. 3,

ditto from Red Crater; No. 4, ash on slope of Tongariro; No. 5, augite-andesite, the lava of 1869, Ngauruhoe; No. 6, pumice from North Crater, Tongariro; No. 7, rhyolite lava from Motutaiko; No. 8, lithoidite from Hamaria, Lake Taupo.

Other varieties of augite-andesite from Tongariro differ chiefly in the degree of devitrification of the glass, the porphyritic crystals being essentially the same. Specimens may be obtained in which the groundmass is quite free from crystallites, and consists of a pure glass of a rich brown colour. That this was the original condition of the groundmass in the other varieties may be seen from the inclusions of brown glass in some of their larger felspars. Here we must include specimens of brownish pumice, which contains augite and plagioclase in crystals and groups of crystals—evidently only a similar rock distended with very numerous minute vapour-cavities.

On the side of Ngauruhoe which slopes down to the South Crater on Tongariro, is a lava-stream which is said to have flowed from Ngauruhoe in 1869. This stream ends in an irregular front just where the slope of the cone joins the flat bottom of the crater on Tongariro. The lava is much fissured, and the smooth surfaces of the blocks have a strong glassy lustre. This lava is essentially like those on Tongariro, except that the groundmass is rather more glassy, and is perhaps richer in iron-oxides. The proportion of silica, however (see analysis No. 5), is rather lower, being only 57·0. Its specific gravity is 2·82.

Amongst other lavas of Tongariro may be mentioned that which forms the blocks of lava at the highest point of Tongariro. This contains a few crystals of olivine. The same mineral occurs in crystals visible to the naked eye in the lava which reaches Otouku. This rock is shown by its analysis (see No. 2) to differ but slightly in chemical composition from the commoner type of Tongariro lava. Its structure, however, is very distinct. The porphyritic crystals are not numerous, but include plagioclase, augite, and olivine. The groundmass is almost entirely crystalline, and shows a pronounced fluidal structure. It consists of small augite prisms and minute laths of felspar, with scanty magnetite granules. In parts of the rock a little glass may be traced; in others it appears holocrystalline. The fluidal structure is due partly to the parallel grouping of the felspar laths, but more especially to the arrangement of the augite and felspar in such a way that along certain lines the minute augite crystals largely predominate, along others the felspar laths. The specific gravity is 2·83, being doubtless a little higher on account of the crystalline character of the groundmass.

A rock which occurs in blocks around the Red Crater is

much more basic than any of the preceding rocks. It is heavy and black, with all the appearance of a basalt, and shows microscopic olivine. It contains, however, felspar and augite crystals like the porphyritic crystals in the augite andesites previously described. They are not very abundant, and to them are added olivine in numerous crystals, and felspar laths. The groundmass is in the main crystallitic, but shows far more crystalline particles between crossed nicols, and glass is scarcely visible. The rock thus shows a relationship to the augite andesites, but at the same time approximates to the basalts. Another variety collected by Mr. Cussen contains chiefly olivine among the larger crystals, though a few smaller augites are present. The groundmass is partly crystallitic, but contains very numerous felspar laths.

The analysis of the former variety by Mr. Pond shows (see No. 3) that it contains 52·1 per cent. of silica—an amount considerably higher than that usually present in rocks recognised as augite-andesites. Its specific gravity is 2·94, which also indicates a rock more basic than ordinary augite-andesites. The magnesia and lime are also present in much higher proportion than in the other rocks of Tongariro. Rosenbusch, in his last edition,* states that the augite-andesites seldom contain less than 56 per cent. of silica, whilst some basalts attain the same percentage. Teall quotes twenty-three analyses of porphyrites and andesites as varying between 66·75 and 54·73 per cent. of silica, whilst the same number of basalts showed percentages of silica varying between 53·73 and 42·65.† Under the circumstances, we shall probably be justified in terming the rock a basalt, though we must admit that it is closely related to the augite-andesites. The system of classification of rocks is necessarily more or less arbitrary, and the present rock is one which lies near the line of division between the augite-andesites and the basalts.

Pumice on Tongariro.—We have referred above to the popular idea that the great quantities of pumice around Lake Taupo are derived from Tongariro and Ruapehu, and have stated that the examination of the country to the south of Lake Taupo lends little support to any such theory. Pumice is indeed found on Tongariro, but in comparatively small quantity. A small amount of pumice of an acid character, containing 75·25 per cent. of silica (see analysis No. 6), was found in the North Crater of Tongariro, and one or two small fragments of rhyolites were found elsewhere on the mountain-top. But with these exceptions all the rocks high up on the mountain were of a more basic character. On the lower

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* "Physiographie der Massigen Gesteine," p. 702.
† "British Petrography," p. 49.

slopes of Tongariro, to the north, on the other hand, pumice is found to a depth which may reach 2ft. or 3ft, but often much less, or may be altogether wanting. The deposit was probably thicker once, as some of the streams show small terraces of pumice. This pumice is, however, only a superficial coating: below we find ashes or lavas of more basic composition. On the lower slope of Tongariro, above Papakai, such sections as the following may be observed in recent water-courses:—

	Ft.
1. Black soil	½–1
2. Subsoil, white and pumiceous	½–1½
3. White pumice	½–2
4. Layer of loam, denoting an old soil and subsoil, the upper 6in. darker	2
5. Volcanic ash, fragments weathered brownish, dark-grey when broken open: towards bottom in finer and coarser layers ...	6–10
6. Brown loam, sharply marked off from the former: may represent an old land-surface	1–4
7. Breccia of fragments of lava, apparently augite-andesite.	

Examination of the deeper layers Nos. 5 and 7 shows that they are composed of rocks related to the augite-andesites. An analysis of the ash from layer No. 5, by Mr. Pond, shows 57·9 per cent. of silica. (See analysis No. 4.) The specific gravity was 2·68, affording a similar indication.

We may conclude, therefore, that the eruptions of Tongariro for a considerable period have yielded lavas of intermediate (and basic) composition only. The pumice of acid composition which lies on the surface must have been derived from some more distant source, and of course at a date subsequent to the great eruption of Tongariro which produced the ash of layer No. 5. Seeing how widely the pumice has been distributed in the district, we need not hesitate to make such a supposition; and I may quote as a parallel case the ashes from the eruption of Tarawera which were deposited on the cone of Mount Edgecumbe, at a distance of fifteen miles, to the thickness of 14in.

In concluding, I desire to express my indebtedness to Mr. Percy Smith, Surveyor-General, for topographical information relating to the Taupo district, and to Mrs. J. McCosh Clark for the artistic sketches illustrating some of the geological features of the district which is the subject of the present paper.

EXPLANATION OF PLATES XXVI.-XXXII.

Plate XXVI.—South end of Lake Taupo, showing volcanic mountains.

Plate XXVII.—

Figs. 1 and 2 (from Hochstetter). The cone of Ngauruhoe, as seen by him in April, 1859. Fig. 1, seen from north; fig. 2, from west.

Fig. 3. Ngauruhoe, from Maungatepopo, February, 1887. From a photograph by Mr. A. B. Wright.

Fig. 4. From Papakai, March, 1888. Showing top of crater very much crumbled away. It is very unsafe to walk about, the ground being hot or rotten. The bulk of the steam which issues from the crater is carried by the south-west wind directly over the crumbling lip (A), keeping it almost constantly moist and clear of snow.

Fig. 5. From Papakai, May, 1888. Showing new break in eastern lip (B), which occurred during bad weather, in April or May. B was composed of blocks of lava.

Fig. 6. From east end of Pihanga, June, 1888.

Plate XXVIII.—Tongariro, from near Rotoaira.

Plate XXIX.—Sketch map of summit of Tongariro.

Plate XXX.—North Crater, Tongariro.

Plate XXXI.—Lakes on summit of Tongariro.

Plate XXXII.—Lake Taupo, showing old lake terrace.

IV.—CHEMISTRY.

Art. XLIII.—*On the Manganese Deposits of the Auckland District.*

By J. A. Pond.

[Read before the Auckland Institute, 17th December, 1888.]

The existence of manganese in various parts of this district has been recorded for many years, but it is only during the last ten or twelve years that any large quantity of it has been dealt with commercially. It was first mined on a large scale at Waiheke, and next at the Bay of Islands, since which considerable quantities have been sent from Whangarei. The mines at the Bay of Islands, and also at Waiheke, have been worked extensively, and have yielded a large tonnage of excellent ore while under the successive managements of Mr. Stovin, Captain Phillips, and Mr. Kersey Cooper. At the former place the chief workings were connected by a wire tram with the water, the motive-power being obtained from a stationary engine secured upon a moored punt, the manganese ore being discharged into punts, from which it was transferred to vessels for transmission to Auckland, the shallow water of the bay making it necessary to adopt this tedious method of loading. At Waiheke the ore was carted for some distance to the water's edge, where it was placed directly in the cutters and transferred to Auckland. At this port the ore was discharged into homeward-bound vessels, where it was of value in stiffening the ships which were loading home with wool, and was consequently taken at low freights, proving a valuable ballast owing to its high specific gravity.

In the mines the ore was found in bunches sometimes yielding several hundred tons of ore, which was brought to the dressing-floor and carefully picked over, as it was seldom possible to ship it direct owing to nodules of hæmatite and clay-masses, together with a good deal of silliceous gangue—the "flucan" of the miners—which tended greatly to reduce the value of the ore unless removed. Sometimes this silliceous gangue was stained black by the peroxide of manganese,

and unless great care was taken, and skilled workmen employed, a great deal of this material found its way into the parcel.

As this ore is always purchased upon its assay-value, and every effort is made to obtain a true average sample of the bulk, it will be seen how necessary it was to have the ore as free as possible from foreign material; and, owing to the soft, black, unctuous portions of the ore staining the accompanying worthless material, it was not always possible to do more than free it from a portion of the gangue.

The deposits of manganese ore hitherto worked have been located solely in the manganiferous slates, where they occur, as already mentioned, in irregular patches or bunches, sometimes having for a distance the appearance of a true lode, but seldom for any extent, the irregularity of its borders breaking off without continuance, though occasionally some more extended offset would be carried to another bunch. This peculiarity of the ore has made the mining of it a matter of great difficulty and anxiety.

As I have already mentioned, the mines hitherto worked have been solely in the slates; but this ore occurs in many other parts of the district than those already mentioned, notably at Kawau, where specimens of very fine ore have been obtained; again, at the island of Pakihi it has been mentioned as occurring in large quantities, by Professor Hutton.* I have also found it in the Mareatia district, where I have no doubt it will be found in sufficient quantities and richness to make it of commercial value. It is also known to be present in the hills to the west of Waipu, where it may be seen outcropping on the track between that village and the caves. Still further north it is found in larger and smaller quantities between Whangarei and the Bay of Islands, and, again, in the vicinity of Mongonui. There is no doubt that large deposits of this ore will be yet discovered when it becomes of sufficient value to warrant extensive prospecting.

The manganese shipped from this port is chiefly psilomelane, though some very fine specimens of pyrolusite have been obtained from Whangarei. From this part of the district—Parua Bay—some samples containing very high percentages of peroxide have been lately shipped.

The necessity of shipping nothing but high-grade ore is on account of the home market requiring nothing below 70 per cent. of peroxide when purchased for bleaching purposes, as the consumption of hydrochloric acid for the manufacture of chlorine is less the higher the percentage of peroxide present

* "Trans. N.Z. Inst.," vol. i., p. 126.

for a given quantity of chlorine; and, as it is purchased on the assay-value of peroxide present, the freight and shipping charges are proportionately less to its value. In this case, however, we are viewing the percentage of peroxide, and this alone is of value for bleaching purposes; but during the last few years an extensive demand has sprung up for manganese for the purposes of produciug an alloy with iron to form spiegel, manganese bronze, &c., and in this demand the form of oxide in which the manganese is present is not of so much moment as the extent to which the metallic element itself is present is concerned. Hence the lower oxides of manganese are available for this purpose; but in this case it is required to be as free as possible from phosphorus, sulphur and earthy matter, silica, &c. Both of these elements—phosphorus and sulphur—are pernicious in the manufactured spiegel, and every effort is made to procure samples as free as possible from these objectionable materials; the objection to the silica being chiefly on account of the loss of iron in the process of fusion, by the combination of silicate of iron in the slag. Frequent inquiries reach me from England as to the presence or otherwise of cobalt in our manganese ores, while sometimes I am asked as to the presence of a payable percentage of copper. Hitherto I have not found cobalt in these ores beyond traces, though I have found it in combination with the manganese wads, a matter which I have already brought before the Institute. With regard to copper, I have not found it in combination with any of the ores examined by me, though I have made analyses of several samples brought to me and purporting to be copper-bearing.

The effort to ship only high-class ores has resulted in such samples being fairly free from gangue in some instances, though in others they reach 20 per cent., the iron-oxides present varying from 4 to 10 per cent. In a few instances I have examined these ores for phosphorus, and find it present to the extent of from 0·188 to 0·3 per cent., though it may very probably run higher in some samples.

By the advance of scientific research, and adaptation of knowledge so gained, means have been found in the manufacture of bleaching-powder, in which the great bulk of the manganese is used, to recover the spent ore, and re-utilise the material an unlimited number of times. The cost of this recovery, however, is at present a known quantity, and this cost largely governs the market-value of the ore. In consequence of this the price of manganese has greatly receded during the last few years, and it is now not much more than one-half the value of its selling-price in the London market during 1880–82. This has naturally largely governed the output of our district, which at one time promised to

become a considerable item. The shipments for some years are as under:—

Year.	Quantity in Tons.	Value.
1878	... 2,516	... £10,416
1879	... 2,140	... 8,338
1880	... 2,611	... 10,423
1881	... 1,271	... 3,283
1882	... 2,181	... 6,963
1883	... 318	... 808
1884	... 601½	... 1,716

Another factor which will probably determine the shipment of a much smaller quantity than formerly is the carriage of goods to New Zealand by steamers, to the displacement of sailing-vessels, the latter alone requiring ballast.

In the event of other demands arising, and so causing an increase in the price of manganese ore, it is probable that an impetus will be given to its production here, in which case the reduction of the cost of producing it would become a necessity; hitherto the tools and means of dressing it being of the simplest, while the high price of labour and cost of exploitation has proved inimical to its competing with other parts of the world which also produce it in large quantity and of fair percentage—notably Spain, Russia, and Italy.

Art. XLIV.—*On the Occurrence of Tellurium in the Thames Lodes.*

By J. A. Pond, Colonial Analyst.

[*Read before the Auckland Institute, 22nd October, 1888.*]

In the year 1884 I received some rich stone from Mr. E. H. Whitaker, whose assay showed it to contain silver to the extent of 3,928oz., and gold 234oz. to the ton. This was from the Moa Claim, at Te Aroha. The suggestion to examine these specimens for tellurium was given by Sir James Hector, to whom I submitted them, and who confirmed the fact of tellurium being present on his return to Wellington. In the meantime I had determined the constituents of the ore, the analysis of which I append.* This exceptionally rich stone naturally led to further investigation of the ground, showing that it occurred in exceedingly narrow veins, occasionally widening to the width of an inch, or slightly more. In the richer portions the telluride is accompanied by anti-

* Analysis not received.—Ed.

nronide of silver and free gold. The telluride is irregularly disseminated throughout the stone in the massive state and also in fine granules. In colour it is steel-grey, with metallic lustre, and it is readily crushed. It is always accompanied by magnetite in fine grains, and sometimes by ilmenite.

Anticipating that it would be found in other portions of the district, I have examined a large number of the richer portions of the lodes, with the result of finding it in combination with the silver in the Crown, Woodstock (Maria Reef), and Ivanhoe Mines, at Karangahape; in the Champion and Lord Nelson Mines, at Te Aroha; and as a trace only in the Rosemont Mine, at Waihi. That this metal is present in much larger quantities than is generally anticipated I feel convinced, and when proper examination of the ores is made before treatment we shall find a great deal more consideration given to the presence of tellurium than has hitherto been the case. Experience already gained elsewhere has shown this metal to be very inimical to the saving of gold or silver combined with it; and, as I have found it present in some of the Crown ore to the extent of 4·18 per cent. it will be seen that it is a factor which will require to be considered when an economical and satisfactory mode of saving the riches of our lodes is adopted.

ART. XLV.—*On the Preparation of Artificial Chromes for Ornamental Purposes.*

By WILLIAM SKEY, Analyst to the Geological Survey Department.

[*Read before the Wellington Philosophical Society, 22nd August, 1888.*]

THE great beauty of some of our native mineral chromes has no doubt incited others besides myself to attempt their imitation, but, so far as I know, no process for accomplishing this has yet been discovered.

In 1870 I found that in the case of chalcopyrite a very beautiful iridescence was induced upon it, in parts, by making it the negative end of an electric battery;* but there was not that thoroughness or certainty in the process necessary to give it an economic value. However, I still kept in my mind the idea of imitating nature, and at different times made experiments with that object, but until quite recently my efforts have not been attended with much success.

It is well known that the fine play of colours displayed

* "Trans. N.Z. Inst.," vol. iii., p. 223.

by native iridescent minerals is caused by the action of thin films of matter upon light—in fact, by what is termed *interference*. In order, therefore, to beautify with colour where nature had stopped at form, it was necessary to find an insoluble substance, unaffected by either air or moisture, but at the same time transparent, and capable of attaching itself firmly in smooth coherent films on those minerals which are the best reflectors of light.

It gives me great pleasure to inform you that my efforts in this direction have been completely successful, as may be seen by an inspection of the exhibits on the table. I shall now proceed to place before you the results of my investigations.

While experimenting with hyposulphite of copper for another purpose, I observed that a portion of the cupric sulphide which I had precipitated therefrom by heat had attached itself in a continuous transparent film to the vessel containing the solution. The idea of utilising such films for chromatic purposes at once suggested itself, and I accordingly plunged various fragments of metallic sulphides into the boiling solution of cupric hyposulphites, and was gratified to find that in a few minutes they had all become enfilmed to such an extent as to appear in the sunlight of a ruby-red colour. I also found that by longer immersion all the colours of the spectrum could be obtained.

The films producing these colours, even while wet, were found to adhere to the sulphides so tenaciously as not to be removed without the aid of solvents. To test the cohesion of the film as applied to galena, I gummed a piece of paper on to it, dried it thoroughly, and then tore it off forcibly, without the least injury to the film. In the case of stibnite similarly treated, much of the film came off with the paper. On this account I am inclined to think that the surfaces of the galena had chemically united with the inner surface of the cupreous film, thus forming a compound sulphide.

To produce the very best effects with these films it is necessary to operate upon the fresh surfaces of opaque crystals, as these are the most highly reflective of any mineral surface that we know of. So far as I have yet pushed my experiments, the best minerals to use for this purpose are arseno-sulphide of nickel, mispickel, galena, and stibnite.

Specimens of the last two, both in their natural and artificially-coloured states, are on the table. The more lustrous of our cokes also take on a very brilliant green.

After repeated experiments for other substances capable of forming adherent films on glass or native minerals, I find that the following do so as precipitated from alkaline hyposulphites: sulpho-arsenide of silver, sulpho-arsenide of copper,

and sulpho-arsenide of cobalt. All these, however, are of too dark a colour to permit of their use for ornamental purposes.

The best way to obtain cupric-sulphide films upon minerals is as follows: One pound of hyposulphite of soda is dissolved in two pints of water, and then mixed with an aqueous solution of commercial sulphate of copper, consisting of 1oz. of the salt to eight parts of water. A little more or less of either salt may not matter much, but what is absolutely necessary is to have a large excess of the hyposulphite, which is known by the thorough discolourization of the cupric compound. If too little is used a brown film of cupreous sulphide forms, which is not sufficiently transparent for the object in view.

The mineral to be treated is attached to a piece of string and plunged into about ten times its bulk of the mixed solution, to which heat is then applied. Just as it begins to boil the liquid turns green, and cupric sulphide is precipitated, principally as a black incoherent powder; a small proportion, however, attaches itself to the mineral and to the sides of the containing vessel. About half a minute after the solution begins to boil the mineral should be lifted out for examination. The first colour to show is, in the case of galena, a ruby-red; then, in turn, as the immersion is prolonged, yellow, emerald, green, blue, black-blue, and so on, in the reverse order of the spectrum as usually stated.

Should the mineral, by too long immersion, pass beyond the desired colour, an aqueous solution of ammonia will restore the requisite hue by reducing the thickness of the film; whilst, should it be necessary to remove the film altogether, a strong solution of cold cyanide of potassium will accomplish this at once and leave the specimen itself quite uninjured, this salt having little effect on the common sulphides.

So far I have dealt only with opaque minerals. In the case of transparent objects it was necessary to find an opaque and lustrous substance capable of being deposited in the same manner as cupric sulphide, and upon whose outer surfaces a film of cupric sulphide could be deposited with the same effect as when these massive sulphides were used.

After several experiments I was successful in finding this reflecting background—namely, sulphide of nickel, which can be precipitated in thin films from its hyposulphite solution. Two operations are therefore necessary to coat transparent objects such as glass with iridescent cupric sulphide. They must be first enfilmed with sulphide of nickel, as precipitated from its hyposulphite, and afterwards coated with the cupric sulphide by the process already described.

It only remains for me now to inform you what I consider the exact nature of the films which, by their action on light, afford the very beautiful colours of the specimens in the jars before you.

These films are pure protosulphide of copper, and are therefore of precisely the same chemical nature as the mineral covelline.

In chemical and mineralogical works covelline is described as an opaque mineral. This is no doubt true as regards its massive form; but, as it appears of a purplish colour by reflected light, it should certainly show the complementary colour to this—namely, green—when viewed in thin sections by transmitted light. An inspection of the thickest of the films on the glass slides will prove that, like covelline, they reflect a purple or purplish-blue colour.

That the nature of the films is as I have asserted, is capable of further demonstration by the aid of the electrical instruments on the table. Both the films and the covelline, when connected with the poles of the small battery, allow an electric current to pass along them, as can be seen by the vigorous movement of the galvanometer. That cupric-sulphide films are fairly good conductors of electricity is shown by the fact that even the thinnest red-coloured films, when deposited on stibnite, which is itself a non-conductor, conduct the current, and they do this without being at all disrupted or heaved into corrugations, contrary to what I found in 1860 to be the case with films of silver deposited upon glass by organic matters from argentic salts, when subjected to a similar test.

These artificially-produced films are also of the same nature as those on bornite and peacock copper ore. These natural films are likewise conductors of electricity, and, like those deposited on glass slides and galena, are quickly removed by cyanide of potassium, the resulting solution containing copper and sulpho-cyanogen.

Before these investigations, I had the opinion, in common with many others, that these natural films were metallic oxides; but the electric battery applied to them at once disabused me of this erroneous belief, and led me to the application of the cyanide test, by which their real nature was quickly demonstrated.

The beautiful iridescence, then, which nature has given to certain of the copper ores is clearly due to films which are of the same character as those deposited on the exhibits now before you: but the processes by which each is accomplished are very different—that of nature being by the simple oxidation and removal of the sulphide of iron from the compound sulphide, leaving the cupric sulphide behind; that of man by the

deposition of the metallic sulphide from its hyposulphite solution. Still, the material is the same in each case, and I doubt not but that, as deposited upon the comparatively fixed minerals, the artificially-produced film will prove to be quite as durable under ordinary atmospheric conditions as those which nature has so laboriously and sparingly deposited.

In conclusion, I would draw your attention to the artificially-prepared chromes on the table, and to the glass slides, on which, at the suggestion of Mr. McKay, I have spread a quantity of the covelline-coated galena sand, in order to show the adaptability of these chromes for ornamenting picture-frames.

ART. XLVI.—*On the Fallacy of the Electro-capillary Theory.*

By WILLIAM SKEY, Analyst to the Geological Survey.

[*Read before the Wellington Philosophical Society, 3rd October, 1888.*]

Two theories have been advanced by scientists to explain the action which takes place when aqueous solutions of potassium sulphide and cupric sulphate come in contact with each other in Becquerel's electro-capillary cell.

Becquerel, who originally discovered this phenomenon, and who by its means afterwards produced, or, rather, imitated, a large number of natural minerals, supposed it to be due to a combination of a physical force with that of electricity, to which he applied the term "electro-capillary action." Speaking of the deposition of the copper, he says, "The two liquids, acting on one another through the capillary space, form a galvanic couple, the circuit being completed in the first instance by certain parts of the walls of that space, and afterwards by the separate metallic particles. The correctness of this view may be shown by dipping the ends of a bent copper wire into the tube-apparatus above described, so as to form an ordinary galvanic circuit of two liquids and a metal. The end of the wire dipping into the alkaline solution is then attacked, and forms the positive pole, while that which dips into the copper solution forms the negative pole, and becomes covered with metallic copper; at the same time thiosulphate and nitrate of sodium are formed, and the copper nitrate is decomposed; but no trace of metallic copper is formed, either on the crack or on the adjacent portions of the tube. As soon, however, as the wire is removed, the crack and the inner surface of the tube become covered with metallic copper. This shows

that in the absence of the wire its conducting function is discharged by certain parts of the walls of the capillary space." He further says that the chemical action between two liquids separated by a capillary partition is determined mainly by the magnitude of the electro-motive force; and that the intensity of the electro-capillary current depends upon the chemical attraction between the liquids, and the size of the pores, the diameter of which should be such that all the electricity produced by the contact of the liquids may be utilised for the production of the current.

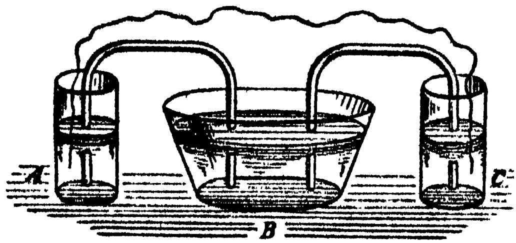
Loew objects to this hypothesis, and in the "Journal of Practical Chemistry" says he is of the opinion that all Becquerel's results may be explained without calling in the aid of electric currents, and he proposes to designate the mode of action by the name of chemosmose.

Loew supports his opinion by stating that when a crystal of cupric sulphate is immersed for some hours in a solution of potassium sulphide, there will be found under the black crust of cupric sulphide which rapidly forms on the crystal a quantity of metallic copper. He says that when a crust of cupric sulphide is once formed the process of decomposition will go on as before only when the molecular gaps (in the crust) are wide enough to allow of the passage of more molecules of potassium sulphide, whilst when the gaps are too small chemosmotic decomposition or electro-capillary action will be produced. The potassium unites with the group SO_4, metallic copper being separated, while the sulphur previously combined with the potassium remains outside the crust, forming potassium disulphide. In reality he assumes that osmose, as favoured by capillary spaces, supplements the effects of chemical action, and under the influence of the newly-formed power potassium sulphide is decomposed into its elements.

Now, it is clearly to be seen that both these scientists set a high value upon capillary spaces or minute pores, for they certainly wish to inculcate the idea that these possess the property of greatly intensifying chemical force—a theory so much at variance with the conclusions I have arrived at that I now propose to show you that these so-termed electro-capillary deposits of Becquerel and the chemosmotic deposits of Loew are simply the product of chemical action unaided by any other force.

The affinity of the sulphur of potassium sulphide for the copper of cupric sulphate is so strong that at the moment of combination an electric current is generated sufficiently intense to deposit copper from its solution; a fact which may be easily demonstrated by a slight variation of Becquerel's apparatus, so as to exclude the possibility of capillary action being in any way connected with this phenomenon.

Solutions of potassium sulphide and cupric sulphate are connected by two siphons filled with a solution of sodic chloride, as shown in the accompanying diagram:—



A. Potassium sulphide. B. Sodic chloride. C. Cupric sulphate.

In the solution of potassium sulphide a plate of sulphurised platinum, galena, or covelline is placed, and this is connected with a platinum electrode placed in the cupric sulphate. In a short time it will be found that the platinum which has contact with the cupric salt is covered with metallic copper, and it may be observed that this effect is produced before any film or precipitate of cupric sulphide or any other compound has formed. Clearly, then, in this instance no portion of the effect is due to capillary or osmotic force.

In Becquerel's so-called electro-capillary apparatus what really takes place is this: The first action is the formation of sulphide of copper in that part of the fissure joining the two solutions which is contiguous to the potassium sulphide. This blocks the fissure at that point, cuts it off from the sulphide, and produces a measure of electric force—in fact, a current—which, being conducted by the sulphide, finds its way to the copper solution by another part of the fissure, and, manifesting itself on the opposite side of the cupric sulphide, thereon deposits copper, which under the circumstances, being protected by a crust of cupric sulphide and the walls of the fissure, does not sulphurise, but remains as copper and forms a nucleus for succeeding metallic deposits.

Through the wider parts of the fissure the liquids slowly mix, and the cupric sulphide which forms there continues the electric currents, and so carries on the electro-deposition of copper in the fissure or along the walls of the vessel containing the metallic salt. If the wider part of the fissure is under a certain width the cupric sulphide forming may completely dissolve in the sulphide solution, and so keep the space open for the electric current.

The narrow fissure is no doubt necessary for these results, which, however, can certainly be produced by electric action without being in any way aided or supplemented by capillary force.

A wide fissure allows the diffusion of the liquids to such an extent that each atom of copper as it is reduced is immediately sulphurised, and so there is no metallic decomposition manifested. The narrower fissure allows of an electrical current being set up in one direction, thus favouring metallic depositions, and this solely by limiting the chemical action to a certain line or point. On the other hand, while wide fissures do not prevent the production of electrical currents, they hinder any ocular demonstration of their presence. The liquids mix in a confused, irregular manner, whereby innumerable currents are set up, which, having no determinate direction, either neutralise each other or form only minute metallic deposits, which almost simultaneously with their formation are sulphurised to the cupric sulphide, and thus become obliterated.

I shall now pass on to a criticism of those minor statements of Becquerel's communications upon this subject which also appear to me to be erroneous.

His suggestion that the walls of these capillary fissures conduct a current of electricity before copper is deposited thereon seems to be wrong for two reasons. First, there can be no electric current produced until copper sulphide has formed in the narrow part of the fissure; and this compound, being, as I have already shown, an excellent conductor, will certainly conduct the current. Second, as glass—the material Becquerel used for his cell—is a dielectric, and the solutions electrolytes, it is manifest that the current was conducted by the saline solutions filling the fissure itself, and not by means of its walls.

His assumption that the copper which is deposited in his cell or any part of it is due to the decomposition of the cupric sulphide is very difficult of belief. It is well known that this sulphide is a very fixed compound, the affinities of its elements for each other being very strong. Neither potassium sulphide nor cupric sulphate separately have any reducing effect upon it, and it is very improbable that any product arising from their interaction would be able to effect what they separately could not do.

In his controversy with Loew regarding the deposition of copper in capillary spaces Becquerel is undoubtedly correct in affirming the existence of electric currents; also in assuming that these are used in the deposition of the copper. His error consists in the assumption that capillarity is necessary to supplement and complete the action.

In regard to Loew's own results with cupric-sulphate crystals placed in a solution of potassium sulphide, they show that even here electric force has had a large share in producing them—that his experiments, in fact, are merely a modifica-

tion of those of Becquerel. Thus, his crystals form a series of narrow fissures or spaces between them and the bottom of the vessel in which they are placed, also a further series with the crust of cupric sulphide which forms around them, and in these spaces metallic copper is deposited by the same cause as that operating in Becquerel's cell.

On repeating Loew's experiments I have always found that the copper is deposited in a solid film on the containing vessel, and in nuggets equally coherent, proving that a concentration of the metal takes place. Each separate deposit of copper undoubtedly performs the part of the negative pole of a galvanic battery, this polar condition being due to the fact that they are preserved from the attack of the sulphide by cupric sulphate and cupric sulphide, with which they are surrounded. Under these circumstances electric currents must be produced, and without these to concentrate and locate the deposits the copper could not be so compact and aggregated.

Chemical decomposition alone, with its constant concomitant electricity, is certainly competent to produce all the phenomena that Becquerel and Loew have discovered. There is therefore no need, in order to explain the deposition of copper in a fissured cell, to assume that either capillarity or osmose intensifies the current of electricity.

I will only add that I have all along strictly confined myself to a discussion of the theories of Becquerel and Loew as applied to explaining the deposition of metals and metallic compounds in narrow fissures or minute pores; but if my criticisms and theory are correct, the idea of electro-capillarity as a compound force present in vegetable and animal organisms will also have to be given up. Here, as in Becquerel's cell, the only use of the capillary space or fissure is to preserve for a time that which chemical or electrical forces have produced, and this simply by the mechanical limitation which it sets upon their operations in the organisms which I have named.

ART. XLVII.—*On the Occurrence of Native Lead at Collingwood, and its Association with Gold.*

By WILLIAM SKEY, Analyst to the Geological Survey.

[*Read before the Wellington Philosophical Society, 3rd October, 1888.*]

(Abstract.)

A NUMBER of small rounded pieces of a soft malleable substance were forwarded to the Geological Survey Department by Mr. Washbourne, as lead, covered with the carbonate, and upon

some surfaces exhibiting spangles of gold. They have a great scientific interest, owing to the fact that the gold is in actual contact with the lead—often, indeed, completely surrounded by it.

The quantity of this substance was too small to allow of a complete analysis being made, but so far as I have tested it the lead appears to be unalloyed with any metal whatsoever.

Mr. Washbourne informs me that these plumbiferous nuggets were taken out of a "pothole" under 12ft. of solid earth and gravel.

I should state that lead but rarely occurs native, and I am unable to find any record of it having been found either alloyed with gold or containing gold as a separate metal.

V.—MISCELLANEOUS.

Art. XLVIII.—*Sanitary Sewerage.*

By H. P. Higginson, M.Inst.C.E.

[*Read before the Wellington Philosophical Society, 9th January, 1889.*]

The question: "How shall sewage be dealt with?" is one that has been found extremely difficult to answer. It has occupied the minds of sanitary reformers for many years, and been treated in a variety of ways, not always successfully. At all periods of the world's history where civilisation attained to any degree of refinement sanitary measures were adopted. It is usual to discuss the question intermittently until the time at length arrives when action must be taken. A virulent epidemic forces the matter to the front in a most unpleasant manner.

The site of the City of Wellington in its original state consisted of hill-slopes falling on all sides towards the harbour, offering ready means of drainage, requiring little experience or thought in the carrying-out. Modern improvements and the expansion of trade have necessitated the reclamation from the harbour of the whole frontage; and though on the one hand this has covered the foreshore upon which sewage-mud festered in the sun to the annoyance of the citizens and detriment of the public health, on the other hand it has greatly increased the difficulty of constructing a properly effective sewerage system, as where the sewers traverse the reclaimed area they become tide-locked twice in twenty-four hours, with the result that, their contents being impounded, the loss of velocity is the cause of the deposition of the solid particles. This, in the form of sewage-mud, becomes mixed with road-detritus and material washed from the hill-slopes during heavy rains, gradually forming an ever-increasing deposit which solidifies to such an extent as to withstand the action of even the rush of water during heavy rainfall. When this accumulation threatens to block up the outlet it must be removed by hand-labour.

The worst feature of this stagnant deposit with which sewage-mud is incorporated is that it generates foul gases,

which force their way upwards through the drains to the higher levels of the city. As the reclaimed land becomes more densely populated this evil will be more severely felt, and will most assuredly mark its effect upon the death-rate.

Many hold the opinion that the sewage of 30,000 inhabitants, if allowed to flow into a body of water the size of Wellington Harbour, becomes lost in its immensity, and that no evil result is likely to accrue. When it is considered that the flow of noxious matter is going on continuously at an ever-increasing rate, and that a great portion is deposited upon the bottom of the harbour in front of the city, it will be seen that it can only be a matter of a few years till, with these constantly recurring effects, our beautiful harbour, the chief pride of the citizens, will become a source of annoyance and disgust, instead of a pleasure and delight.

It has been asserted that sea-water rapidly becomes fouled by such discharge into it, especially where nearly landlocked, and consequently not swept by strong currents. As the population increases and other drainage arrangements are carried out, the difficulty of introducing an entirely new system, however meritorious and advantageous, becomes more and more felt, and presents a problem to be solved which, owing to the difficulty attending a satisfactory solution, is naturally shirked by those directing municipal affairs. In older countries, where towns have for many years been sewered upon some system or other (in many cases very unscientific ones), this difficulty has been much felt; notwithstanding which it has had to be faced, consequently the sanitary condition of many towns has been greatly improved. In England, the Rivers Pollution Act has obliged action to be taken in the case of inland towns.

Baldwin Latham, a recognised authority upon sanitary engineering, in his work upon the subject, remarks that "the good that has arisen from the prosecution of sanitary works wherever properly carried out may be taken as the harbinger of better times, when the benefit of sanitary measures will be better understood and more extensively adopted." Dr. Lyon Playfair, in his address at the Social Science Congress at Glasgow in 1874, gives an example of the gradual improvement in the health of London from the adoption of sanitary measures, when the death-rate fell from 80 per 1,000 during the period 1660–79 to 22·6 per 1,000 in 1871. How much society loses annually from preventible diseases it is impossible to fully estimate, as health is so intimately connected with all the branches of every-day life. If upon no other than economic grounds, it is true economy to spend some little of our earnings in the prosecution of sanitary works."

I will not weary you by repeating the thousand arguments

in favour of sanitary reform, so much advocated of late years, and relating to which a whole library of literature and statistics has been published. We, no doubt, all agree upon the point that the best arrangements possible should be adopted, but at the same time we do not appreciate heavy taxation, and, above all things, if we have to spend large sums in endeavouring to effect the object in view, we should like to feel that the money is not being squandered in useless and, in many cases, positively injurious works. Nor shall I enter upon the subject of the ultimate disposal of sewage: suffice it to say that it is an open question, considered apart from the drainage itself. The fertilising quality of sewage is of great value, and will eventually be made use of more generally, as in the cities of Adelaide and Christchurch. The application of sewage in that manner opens up an economic question, and it becomes one of pounds, shillings, and pence whether it can be made use of for fertilising land, or with greater advantage to the ratepayers be cast into the sea.

It is well known that for many years the Wellington City Council has contemplated the construction of an efficient sewerage system, to which end a report was obtained from Mr. Climie, in 1877. Mr. W. Clark, M.Inst.C.E., an able sanitary engineer, was also employed to report upon the same subject in 1878, and did so in a comprehensive manner: since that date no further steps appear to have been taken towards the attainment of the object, although the latter gentleman's scheme was, I believe, adopted at the time.

I have no intention of criticizing these various schemes, but will mention that Mr. Clark's estimate amounted to £145,000, the working-expenses to an annual sum of £1,434, and the annual charges, including interest on capital, to £10,154. It is to be inferred that the magnitude of these sums has militated against the prosecution of the work.

One of my objects in bringing the subject of this paper before the members of the society is to advocate a system of drainage for Wellington which not only provides a more efficient one than that adopted, but—what is also a very important point—reduces the present cost to little more than one-half.

The system is based upon scientific principles easily understood when a little explanation is afforded, and is known as "Shone's Hydro-pneumatic System," Mr. Isaac Shone, civil engineer, of Westminster, being the inventor, and this system during the last few years he has successfully introduced into many towns in England and other parts of the world.

In carrying the system out water-carriage is essential, and this is universally allowed to be the cleanliest and most

effectual means for conveyance if properly designed and constructed. Baldwin Latham says, "It is the best adapted to the requirements of a town-population for effecting the speedy removal of the principal matter liable to decomposition, the storage of which, even for a brief period, near our dwellings may be attended with dangerous consequences." An efficient and abundant water-supply is therefore necessary, and this the City of Wellington is fortunate in possessing.

By any system the sewers should be entirely free from sewer-gas, the result of fermentation, requiring time to become generated; consequently there must be a rapid and entire discharge of the sewage throughout the whole. In stagnant tide-locked sewers, in those laid with insufficient fall in which solid matters become deposited, and in old wooden or brick drains of faulty construction, this gas is generated in abundance. Ventilation and traps may lessen the danger, but do not remove it.

The Superintendent of Sewers in Boston in a recent report shows that in all sewers there is a constant movement of air in the direction contrary to the grade, the gas flowing upwards through every vent into houses, and through cesspools, thus permeating the atmosphere of dwellings. He proposes to erect a large fan, to be operated by a powerful engine, exhausting the air, and creating a draught in the direction of the exit which shall attain a speed of 3in. per second, thus overcoming the upward movement of the gases. It is evident from the foregoing that the Boston sewers are not constructed according to modern sanitary laws. So important is the subject of ventilation that Baldwin Latham devotes over a hundred pages to it in "Sanitary Engineering."

In carrying out the ordinary systems of sewerage in low-lying districts ratepayers are subject to three varieties of heavy expenditure—

(1.) Initial, which is the cost of constructing sewers.

(2.) Chronic, being the cost of raising the sewage by pumping.

(3.) Intermittent, being the cost of repairs and freeing the sewers from stoppages—a serious item where the works are of faulty design, and much increased where, in order to obtain the necessary inclination, the sewers have to be placed at great depth.

The "Shone" system greatly lessens the danger, expense, and inconvenience, for reasons which I shall shortly endeavour to explain.

It is generally allowed that the separate system is to be preferred, both on the score of efficiency and cost, especially where sewage must be raised by the expenditure of power. This was, I believe, advocated by both Messrs. Climie and

Clark, though the latter admitted a large proportion of rainfall. In explanation of the term, I may state that only the house-sewage is admitted, the surface-water and ordinary drainage being carried by distinct drains into the natural watercourses, and so to the nearest river or sea, as the case may be. By the adoption of the separate system we are enabled to calculate almost exactly what quantity we have to deal with, as the discharge will closely correspond with the amount of water supplied to the population for domestic purposes, and we are not called upon to provide for an unknown quantity, which must be the case when the rainfall is admitted.

The separate and hydro-pneumatic systems are in no sense interdependent parts of one scheme, the only connection between them being that the cost of the introduction of the "separate" system is very much reduced when compressed air is made use of in ejectors.

The application of compressed air as a transmitting medium has been of late extensively adopted in a variety of ways. There is nothing visionary or unpractical in urging its adoption, for it has been indorsed with the approval of most practical men of our time. Where the burning of town-refuse in a "destructor" furnace is carried out we have the power for compressing the air free of expense. It is a motive-power which, once produced, can be conveyed and divided amongst any number of stations at varying distances with little loss. It is open to question whether the use of air or water can be most economically adopted for the transmission of power. This has been much debated of late. Suffice it to say that for the purpose of transmitting sewage by Shone's system air is alone applicable. The loss from friction in the pipes is much less for air than water, and its compression is now well understood, rapid strides having of late been made in the perfection of the necessary machinery for the purpose.

In properly designing sewers one of the chief objects to be attained is that they shall be self-cleaning—that is, they shall be laid at such inclination as will generate a velocity which will prevent deposit. Where this is not the case they rapidly fail to act, necessitating constant expenditure to free them from obstructions, which is the source of the foul gas so deleterious to the occupants of houses with which they are connected.

Baldwin Latham states that "undoubtedly an open drain is the least injurious form of sewer, provided stagnation is avoided, and that in proportion as the sewers are enclosed the danger to health is increased. The usual remedies are to trap, ventilate, and flush the drains—measures which only succeed in partially remedying a defect that should not exist."

In flat districts where sufficient fall has not been provided these results are always to be found, and can only be obviated by deep and expensive sewers leading to a pumping-station, or by the adoption of the principle I now advocate.

By pneumatic pressure an artificial head is provided, which forces the contents of the intercepting sewer or pipe at a proper velocity along its whole length, regardless of its inclination, to the outfall. This artificial head takes the place of the natural head upon a gravitation sewer, and gives the requisite velocity to its flow. For example, with an 18in. pipe one mile in length, discharging 318 cubic feet per minute, the velocity of its contents will be 3ft. per second. The fall in a gravitating sewer to bring about this result would be 1 in 350, the height or head necessary to overcome the friction in the pipe being 15·1ft. By Shone's system we force the contents into and along the pipe (which can be laid on the level) at a pressure of 6·553lb. per square inch, that being the equivalent of a head of 15·1ft., the result in both cases being the same.

In the gravitating pipe we must have a natural fall of 15·1ft., and lay it below the hydraulic grade-line at a probably heavy expense. By Shone's system we may have no fall whatever, laying the pipes upon the undulating surface of the ground at the least possible cost. We must, however, supply 318 cubic feet of air at a minimum pressure of 6·553lb. per square inch, with which the sewage is forced into and along the pipe.

If it can be shown that to supply that quantity of air under pressure is less expensive than to gravitate the sewage to a pumping-station, and then lift it to a height corresponding to the loss of head, the pneumatic system must be preferable, even when other results are equal.

We will take the schemes as proposed for draining the low-lying parts of Wellington as an example.

By Clark's scheme the sewage from this area was to be collected by an expensive brick intercepting sewer terminating at a pumping-station where the sewer would be 9ft. below high-water mark. Thence it was to be pumped through a cast-iron main nearly a mile in length to a height of 37ft. above the intercepting sewer, where it would join the sewage flowing by the gravitation sewer which was to drain the higher portions of the city, and would thence flow through a tunnel a mile and a quarter long to the sand-hills near Lyall's Bay.

By the pneumatic system cast-iron mains are substituted for brick intercepting sewers, and are only laid sufficiently below the surface of the ground to keep them out of sight and free from damage. Into this cast-iron main the sewage

from the lower areas is forced, that from the higher areas flowing by gravitation, the branch mains receiving it being carried up to an elevation sufficient to establish a head which will overcome the friction in the mains, thus enabling the whole to flow together to the outfall.

From the Corporation Yard, where the air-compressing station would be placed, the outfall main would be carried along the shore of the harbour and Evans's Bay to the same point on the sand-hills as by Clark's scheme; or, if necessary, to Lyall's Bay.

Mr. Clark, however, dealt with the sewage of a population of 70,000 and a rainfall of 1in. flowing off one-quarter of the area occupied by the city; while I propose to deal with the sewage alone of 50,000, leaving the rainfall to flow off by existing drains, and when the population exceeds 50,000 to extend the system, thereby avoiding the necessity for incurring a heavy present outlay for the benefit of future generations.

The pneumatic system can be readily adapted to the increase of population, wherein lies one of its chief merits: when the necessity arises additional "ejectors" can be introduced, and, by increasing the air-pressure, greater velocity, and therefore greater discharging-power, can be given to the main outfall pipe until it becomes necessary to duplicate it—a work readily done without in any way interfering with the works previously constructed. By Clark's scheme the intercepting sewers and long tunnel can only discharge a certain volume of sewage and rainfall; while to increase their capacity, which must eventually become necessary, means a very heavy outlay. By admitting so large a proportion of the rainfall to the sewers he has enormously increased the first cost and working-expenses of his scheme. It may have been done with the object of flushing the sewers; but I maintain this can be more effectually done by the adoption of automatic flush-tanks at the head of the sewers.

I will now describe the "pneumatic ejector" and its action.

From a central station, placed where most convenient, compressed air is forced through small pipes to the various ejectors, which are placed at the lowest point of each subdivision which it is intended to serve. Each ejector-station has its own particular system of pipe-drains leading into it from such subdivision, which, being of comparatively small extent, enables these pipes, even in flat ground, to be laid to proper self-cleansing gradients without burying them at a great depth. A drain-pipe 20 chains in length laid to an inclination of 1 in 250 will only have a vertical fall of 5·4ft. This fact is one of the important features of this system, long lengths of sewers being

unnecessary, as from preference another ejector-station would be inserted. From the gravitating pipes or sewers the sewage enters the bottom of the ejector, a spherical cast-iron vessel usually holding 350 gallons, and 5ft. in diameter. In the inlet-

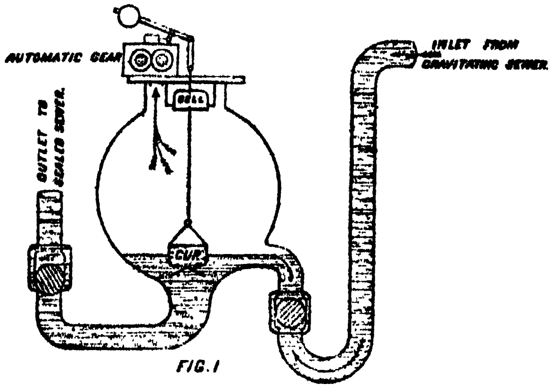


FIG. 1

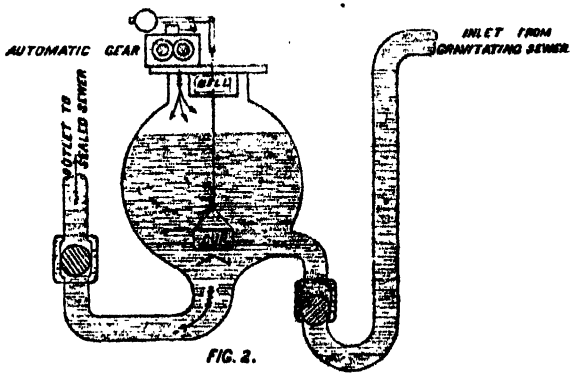


FIG. 2.

pipe is a ball-valve which closes to prevent the return of the sewage. Upon the ejector being full (fig. 2) a bell-float actuates an automatic gun-metal valve placed on the top of the apparatus admitting air under pressure, which at once forces the contents through another ball-valve into the outfall main or sealed sewer. When the ejector is empty (fig. 1) the descending cup actuates the valve, releasing the compressed air, upon which the ball-valve in the outlet-pipe closes, while that in the inlet opens, when the sewage enters as before. This action can take place about once a minute, and is perfectly automatic, having been proved to work for several years without attention except an occasional oiling.

The ejectors are placed below the level of the street and are free from all objection; while in practice they are provided

in duplicate, in order to guard against the possibility of stoppage from accident. From the dwelling-house to the ejector the sewage flows uninterruptedly, and upon entering the ejector the sewage is practically done with, no back-flow even of gas being possible. The velocity of 2½ft. per second will convey sewage through a mile of pipes in thirty-five minutes, so that there is no possibility of gas being generated under proper conditions.

The whole apparatus is exceedingly simple, and, having few working-parts, is little liable to damage, and costs equally little for repair. The air-valves are constructed of gun-metal, and occupy but a small space. The ball-valves in the inlet and outlet-pipes are of hardwood, and are found to pass substances such as hair, string, &c., which are a constant source of trouble to the valves of pumping-engines.

One special feature in favour of this system over Mr. Clark's is, that there is no possibility of sea-water finding its way into the main, while with a brick sewer two miles and a third in length, carried to a depth at one end of 9ft. below high-water mark, the sea-water must find its way in through every crevice and crack in the work. This water has to be pumped out, together with the sewage, at the cost of the ratepayers.

It will be readily understood that there is considerable difficulty in introducing an entirely novel system. Its being based upon scientific principles not thoroughly understood by every one, is quite sufficient to warrant unthinking persons in jumping to the conclusion that it is complicated and liable to result in failure; although the experience of the last few years at numerous places where the system has been adopted has resulted in universal satisfaction being given.

Any improvements in sanitation should become of deep interest to the community; and that must be my excuse for taking up so much of your time. Many people shut their eyes to all matters relating to the subject, leaving it to others whose sphere of life is more intimately connected therewith to work out the problems; and it is as well, perhaps, that it is so, or the discussion would be endless, and we should never arrive at the stage for action being taken.

In conclusion, I repeat that were Wellington sewered upon the pneumatic system the sewage would be rapidly, effectually, and inodorously conveyed from the city in a sealed iron main to any outfall deemed desirable. In such main there would be neither manholes nor ventilators to annoy the public. By the exclusion of the rainfall the quantity to be dealt with could be accurately determined, so that to convey that quantity the sizes of the sewers and pipes could be properly adjusted.

The sewage being discharged in a concentrated form, undiluted with rain-water, its value would be much enhanced as a liquid manure for the purpose of irrigation, should it be decided to employ it in that manner. For the same reason the first cost and working-expenses would be greatly reduced.

Provision for serving a population of 50,000 is, I maintain, ample, the possibility existing of extending the system to meet the future increase without sacrificing the work previously carried out.

The remarks in this paper have, of course, a catholic application: what has been said with reference to the difficulty of draining Wellington applies equally to all towns occupying flat sites, the difficulties which may arise, and sewage-gas nuisances which threaten, being the same.

The pneumatic system has, I venture to submit, solved the problem of how to drain localities effectually and cheaply which do not possess the natural conditions suitable for drainage by gravitation.

Art. XLIX.—*Notes on the Islands to the South of New Zealand.*

By A. Reischek, F.L.S.

[*Read before the Auckland Institute, 30th July, 1888.*]

At last the time came for me to say "Good-bye" to those solitary wilds on the west coast of the South Island where, amidst the grandest and most beautiful scenery, I had spent so many happy days. Truly, nature has lavished her favours on New Zealand, and I may well be excused for being sorry to leave it.

On the 19th January, 1888, the "Stella," under the charge of Captain Fairchild, left the Bluff for her annual tour to provision the dépôts kept up for the succour of shipwrecked sailors on the islands to the south of New Zealand. Mr. Dugald (the photographer), a few youths, and myself were the only passengers. We started first for Stewart Island, distant fifteen miles to the south-south-west. Passing through Foveaux Strait, dotted over with romantic little islands, we disturbed numerous flocks of mutton-birds (*Puffinus tristis*) which were feeding, playing, or sleeping on the water. A few nellies (*Ossifraga gigantea*) followed the vessel to pick up any scraps thrown overboard, which they greedily devoured.

Stewart Island is of irregular shape: its western or longest side runs in a north-and-south direction for about thirty-nine miles; the north and south-east sides are each

about thirty-three miles in length; its greatest breadth is about twenty miles. Passing the eastern side of Wilson's Bay we noticed a few houses scattered about near the shore, and some cattle grazing on the pastures. We steamed through Port Adventure, where the photographer obtained some fine views, and then went on as far as Lord's River, where we anchored. Two boats were lowered: one, manned by the second mate and some sailors, went fishing; the other was in charge of the captain, and this our party accompanied. We pulled up the river, which opens out into numerous pretty little bays. Its banks are low and broken, and densely wooded, mostly with mountain rata (*Metrosideros lucida*), manuka (*Leptospermum scoparium*), rimu (*Dacrydium cupressinum*), and some other shrubs. The scenery was varied and magnificent. We saw a few paradise ducks (*Casarca variegata*), numbers of grey ducks (*Anas superciliosa*) and brown ducks (*Anas chlorotis*); but they were all very shy. Nevertheless, several nearly full-grown young of the latter were caught alive. A small species of weka, not yet described, was caught peeping out between the rocks. Its plumage is rust-red; each feather has a blackish-brown streak in the centre; wings rust-red with black bars; throat yellowish-grey; breast rust-red; abdomen slaty-grey; bill and feet pink, the ridge of the former brown; eyes chestnut-brown. Total length from tip of bill to end of tail, 17in.; wing, 5·5in.; bill, 1·8in.; tarsus, 2in. On the trees overhanging the river numerous shags (*Phalacrocorax glaucus* and *P. varius*) were sitting digesting their last meal. Great numbers of kaka parrots (*Nestor montana*) were flying about warning their mates of our approach, while the bell-birds (*Anthornis melanura*) and tuis (*Prosthemadera novæ-zealandiæ*) welcomed us with their melodious whistles. A full-grown young tui was not sufficiently on the alert, for we saw a quail-hawk (*Hieracidea novæ-zealandiæ*) dart down on it, seize it in his talons, and bear it away to a secluded tree. I shot the hawk while in the act of devouring its victim, and here is the specimen. On returning to the steamer the other boat came alongside laden with fish. Some hapukas weighed 80lb., and there were many trumpeters and rock-cod. The next day found us storm-bound and at anchor off Evening Cove, in the extensive and beautiful harbour of Port Pegasus. Here I noticed the yellow-headed penguin (*Eudyptes antipodum*), so seldom seen by collectors. They were playing about the boat, and some were in the bush feeding their young, which they had in burrows. On land their movements are very ungainly, being a kind of waddling, or hopping walk. A sailor of the "Stella" shot one, imagining it to be a wallaby! During our stay here we noticed a sea-leopard fishing amongst the kelp a short distance from the

vessel. After a while we shifted to Wilson's Bay, twelve miles to the south, still waiting for the storm to abate. On the 21st January a start was made for the Snares, but owing to the terrible weather outside we had to return to the well-sheltered Port Pegasus. On the 22nd another attempt was made, and at 3 a.m. the Snares came in sight.

These islands lie sixty-two miles S. 22° W. from the south-west end of Stewart Island, and extend four and a half miles in a north-east and south-west direction. The north-east island, which is the largest, is little more than a mile in length by half a mile in width, and rises almost perpendicularly out of the sea to a height of 470ft. There are also several outlying rocks. It is volcanic in structure, according to a paper by Sir James Hector,* which contains notes on the geology of the whole of the outlying islands to the south of New Zealand. We anchored in 56 fathoms about half a mile from the eastern shore of the island. A boat was lowered, and we rowed to a little cove or boat-harbour. The birds received us with a chorus of deafening noises, swimming round the boat, and looking greatly surprised at such early arrivals. The island is mostly covered with bush, the akeake (*Olearia* sp.) and kokomuka (*Veronica elliptica*) being the commonest trees. The soil is moist, and largely mixed with guano. There is a little fresh-water stream flowing into the cove, but the water has a nasty taste, and is stained with guano. The whole surface is honeycombed with the numerous burrows of the petrels. Each of our party had his work to do. The captain and the sailors turned out two goats; Mr. Dugald, the photographer, took views; Mr. Hibs had to sow tree- and grass-seeds. I followed the birds, and at once saw three strangers—a black tomtit and a swamp-lark, which were common and tame; and a bell-bird, which was rare and shy. Unfortunately I had brought no gun on shore, and there was no time to return for it, so Mr. Bethune and I chased them, and succeeded in obtaining two, one tomtit and one swamp-lark; both of which I have sent to Dr. Finsch for examination. I have not seen either of these birds before, nor can I find any description of them, so they are probably entirely new. The tomtit was hopping about the lower branches of the trees near the ground, just as the tomtit of the South Island does. It differs, however, from it in its plumage, which is entirely black. Its measurements are as follows: Total length from the tip of the bill to the end of the tail, 5·25in.; bill, 0·75in.; tarsus, 0·9in.; tail, 2·45in. The swamp-lark or utick has rust-brown plumage streaked with dark-brown, top of the head darker; wings dark-brown, edged with light-brown; throat

* "Trans. N.Z. Inst.," vol. ii., p. 176.

and abdomen yellowish-brown with dark streaks; tail and legs yellowish-brown; bill and eyes dark-brown. Total length from the tip of the bill to the end of the tail, 7in.; primaries, 2in.; tail, 3in.; tarsus, 0·9in. It is different in its habits, plumage, and size from the uticks of the mainland (*Sphenœacus punctatus* and *S. fulvus*), which inhabit swamps and deep gullies, where they slip about through the fern or raupo like a mouse, mostly keeping on or near the ground. The utick of the Snares lives in the trees, and its movements are similar to those of the bell-bird, which on this island is darker in plumage than on the mainland. On the cliffs were adult and almost fully-grown young of the molly-mawk, the grey-headed albatross (*Diomedea chlororhyncha*) and the shy albatross (*Diomedea cauta*). The nelly, with its full-grown young, busied itself in the water. With them were mutton-birds (*Puffinus tristis*), diving petrels (*Halodroma urinatrix*), Cape pigeons (*Procellaria capensis*), dove petrels (*Prion turtur*), skua gulls (*Lestris parasiticus*), and mackerel gulls (*Larus scopulinus*). Thousands of penguins (*Eudyptes pachyrhynchus* and *E. chrysocomus*) were on the rocks, standing like regiments of soldiers. It was amusing to see Captain Fairchild, who delights in such sport, tumbling them into sacks, to be taken on board for museum purposes. Many of the young were still covered with down; those full-fledged had a far brighter plumage than the adults. Some disease was amongst them, for heaps of dead were lying about, and the captain and Mr. Dugald came across a perfect cemetery: thousands were lying rotting among the black sand, and the stench was dreadful. I spent a delightful morning, and could have spent a month among the birds, but, the wind freshening, the call was sounded for us to return to the vessel. We got up anchor, and steamed round the whole of the rocks, closely scanning them for any signs of castaway sailors; but, happily, without result. We then turned away, our menagerie of birds on board bidding farewell in chorus to their mates on shore. These are some of the specimens collected.

The vessel was now pointed towards the Auckland Islands, distant about one hundred and fifty miles S. and 5° W. We had very rough weather, westerly winds blowing with almost hurricane force. I had to work under difficulties, for the vessel would occasionally give a violent lurch, throwing me and my tools nearly across the deck, besides giving me a ducking. On the 24th of January we entered the fine harbour of Port Ross, and anchored not far from the abandoned site of Enderby's whaling settlement.

The Auckland Islands are a group consisting of one large island and several smaller ones, and extend over a space of about thirty miles in length by about fifteen in breadth.

They are very hilly and broken, and well watered with many fine streams. The formation is partly granite and volcanic, and partly sedimentary. The lower portions are usually covered with bush, which consists mostly of mountain rata (*Metrosideros lucida*), which grows to a height of 30ft., and sometimes has a diameter of 2ft. These trees have a very pretty appearance from their dark-green shining leaves. There is also the ivy tree (*Panax simplex*), the stink-wood (*Coprosma fœtidissima*)—so called from its bad smell when cut—and a close-growing bush very similar to tea-tree. Open places are covered with herbaceous plants of considerable size and great beauty, such as *Pleurophyllum speciosum*. This is allied to the cotton-plant of the Southern Alps, but is more beautiful. It grows several feet in height, and is covered with clusters of purple flowers. There are two species of *Ligusticum* which are very prominent. The flowers are pink and white, in dense clusters, and the leaves are green, with sharp-pointed divisions. They are closely allied to the aniseed plant growing in the Southern Alps. Another handsome plant is called golden lily (*Anthericum rossi*) by the sealers, on account of the bright-yellow blossoms. Upon the hills the chief vegetation is the tussock-grass, among which are a few flowering-plants, the blue, red, and white veronicas being the most abundant. The ground is often very boggy, and in other places we find only barren rocks.

We landed with a load of timber for a boat-shed. Some sea-lions were amusing themselves on the sand, but they walked lazily away on our approach. The shed was quickly put up under the captain's supervision. The noise of the hammers made animal life active. The sea-lions drew nearer, looking on with surprise. Rabbits, which are very numerous, raced about in all directions. Some wild dogs were sneaking about, but would not come close to us. On Enderby Island were several huts made of tussock-grass, bound together with thongs of the sea-lion's hide. These were constructed by the survivors from the wreck of the "Derry Castle." On the top of the hill was a life-buoy, which they had fixed on a long piece of wood to serve as a signal. After a boat was put into the shed and signboards fixed we steamed up the harbour to the dépôt at Erebus Cove, landing several sheep, and supplying the dépôt with provisions, clothing, matches, tools, &c. Here was the boat in which the survivors from the "Derry Castle" came across from Enderby Island.

On the 25th we steamed up to the head of the harbour known as Sarah's Bosom, putting up signboards to direct shipwrecked sailors to the dépôt. We saw a boat painted blue, also two columns 4ft. high and 1ft. 6in. square, with a flag of cement bearing the inscription, "German Expedition, 1874."

This marks the place where the transit of Venus was observed by the German scientists. From here we went to Ross Island, where numbers of sea-lions were noticed amusing themselves among the tussock. A boat was lowered, and several of us went on shore to drive the clumsy creatures into a group for Mr. Dugald to photograph. It was a most laughable sight. They tried to escape; but, being stopped by the sailors, squatted on their haunches, moving their heads from side to side, giving discontented growls, and looking at each other with surprise. Some of the males were very large, and had fine manes; the females are lighter in colour and smaller in size. They were plentiful, and I was sorry at not being allowed to procure some for scientific purposes; but on account of the close season the Marine Department would not give permission. The fur-seals are very rare and very shy. They inhabit the more exposed places, and are sometimes found in the caves, of which there are many, but usually empty.

We now steamed round North-west Cape towards the south, passing a most interesting sight—perpendicular cliffs standing boldly out, and appearing as if built of huge blocks of all imaginable shapes, the sea dashing on them, and sending the spray to a great height. On some of these cliffs are waterfalls, the water from which was blown upwards by the force of the wind so as to resemble fountains. From a distance they looked like steam-jets. We sailed inside Disappointment Island—a wild scene. The sea was boiling, breaking over the rocks with tremendous force, and sending the spray in all directions. This is the spot where the "General Grant" is said to have been driven into a cave when wrecked in 1866; but we did not see a cave large enough for any vessel to go into.

We now came round the South Cape of Adam's Island—the wandering albatross sailing along with us in hundreds—and called into North Harbour to put up a signboard; from thence we proceeded to Carnley Harbour, and anchored for the night. On the next day, the 26th January, I landed at 4 a.m., being permitted by the captain to spend the whole day on land. It was a delightful morning: the birds sang, the sea-lions grunted and growled at being disturbed so early; some tried to escape, others just sat on their haunches, showing their white canine teeth, too lazy to leave their lair. My path was at first through thick scrub, then through tussock-grass and over bogs and barren rocks. The birds that I noticed were the bell-bird, the blight-bird, the yellow-breasted tit (*Petrœca macrocephala*), the ground-lark, the little parrakeet (*Platycercus rowleyi*), the banded dotterel, and the native snipe (*Gallinago aucklandica*). (In my account of Port Ross I forgot to mention that I went up a creek, where I saw a number of ducks. I approached them very carefully, and was within a few yards

of shooting-distance, when the captain discharged a gun a little distance away. This disturbed them, and they disappeared. They looked like the grey duck—*Anas superciliosa.*)

Now, returning to my hill-expedition, I was delighted to be once more among my feathered friends, and spent some hours watching their movements and procuring specimens. All at once I heard the whistle of the "Stella," and, following down the nearest gully, I saw her steaming up and down the harbour, blowing the fog-horn. It was 2 p.m. I endeavoured to hurry; but my specimens, and the holes, bogs, and dense scrub, made this difficult. During the scramble I fell into a hole. A loud barking growl announced that I had nearly tumbled on the top of a large sea-lion, which had been asleep in it. We both looked surprised. He did not move, but sat up, showing his white canine teeth. I pulled out my sheath-knife, and, keeping my eye on him, scrambled out backwards, and bade farewell to my new acquaintance. At last I came on a sealer's track, which led me to the water, and a boat took me on board; but there were still more on shore who believed in enjoying the whole time promised by the captain, who had done his work sooner than he had expected. When I unpacked my specimens I found that through this hurry I had lost several, and broken nearly all the eggs that I had collected.

Passing Monument Island, with its peculiar-shaped rocks, we anchored a short distance from where the "Grafton" was wrecked. A boat was sent on shore to examine the remains of the vessel, which are scattered along the shore. Captain Fairchild informed me that not far from here is the best anchorage in the Auckland Islands. We next explored the sounds of the east coast, some of which cut far into the centre of the island. In Waterfall Inlet the water is so deep that the steamer's jib-boom was among the trees growing on the cliffs when we were taking in water from a beautiful fall. On the cliffs the sooty albatross (*Diomedea fuliginosa*) was breeding. I also saw six mergansers, and shot two of them; the others concealed themselves among the rocks. Their habits are like those of a duck and not like those of their European allies, which usually escape by diving. Among the other birds seen were the skua gull, the black-backed gull, the mackerel gull, the yellow-billed albatross, the nelly, the Cape pigeon, and the white-headed petrel (*Procellaria lessoni*). I now exhibit the specimens collected on the Auckland Islands.

On the 28th January we arrived at Campbell Island, after a very rough passage. It is 164 miles from the Auckland Islands in a south-east direction, and is about ten miles from north to south, and eleven from east to west. Its geological formation is partly sedimentary and partly volcanic. It is

very hilly, and the faces of the hills are often dotted over with precipices. The greatest height is 1,866ft. There is plenty of fresh water. We anchored in Preservation Inlet, and were stormbound there. So strongly did it blow that Mr. Neil, the chief officer, who was a kind supporter of mine, on going out in a boat to get some birds that I had shot from the vessel, which had two anchors out, was twice blown away from the vessel by the force of the wind. The higher hills were all snow-clad, and it was bitterly cold, westerly squalls, accompanied by hail, frequently passing over. We divided into two parties—one went up Mount Honey, the other Mount Beeman. I went up the cliffs in search of the sooty albatross, several of which were flying about; but as soon as I had shot one the others disappeared. It breeds in the recesses of the cliffs, and is very difficult to get at. It is not so common on these islands as the wandering albatross; but is certainly the prettiest of the family. The only true land-bird noticed by myself on the island was the blight-bird, which is common everywhere. When the Austrian frigate "Saida" was five hundred miles from New Zealand a flock of these little birds came on board. Herr Ritter von Wolf, the flag-lieutenant, wrote me that they were seen sitting on the rigging, and several were procured. I was informed that the tui and a wingless duck inhabit the island; but I did not see any. Wandering albatrosses were plentiful, sitting on a single egg, nearly hatched. On the cliffs exposed to the ocean thousands of molly-mawks (*Diomedea melanophrys* and *D. chlororhyncha*) were breeding. In the water numbers of nellies were swimming about with their full-grown young, which are of a beautiful dark-slate colour. One of the young birds which I saw on shore, when I approached it, walked to meet me, opened its bill, and disgorged a mass of oily matter over me, as if poured from a spout. Its smell was so bad that I had to throw away the clothes I had on. I caught some of the young birds and brought them alive to Wellington; but when I looked for them there I was told by the sailors that they had gone overboard. Cape pigeons were very numerous, and plenty of magellanic shags were fishing with their young. The dépôt at Fuller's Point was supplied with necessaries, some sheep and goats were landed, trees planted, and seeds sown; then we steamed round the island, examining every cove, and sounding as we went along. At North-west Bay there is a remarkable rock, which at a distance looks like a full-rigged ship, but nearer at hand resembles a statue. Sea-lions were very plentiful and very large, but of fur-seals I only saw one. Storms are of almost daily occurrence in these waters, and we rode out one in North-east Bay. On the 31st we left Campbell Island for Antipodes Islands.

On the 1st February it was blowing very hard. The sea was running very high, and the vessel, being light, rolled about like an empty drum. At meals we had to hold on to the table. Sometimes one of the party would roll about in the cabin, plates, dishes, cruet-stand, &c., following him. At night the wind fell, and a hazy fog covered the ocean. Being near the Antipodes, the captain went on very cautiously, and at last we sighted the islands, which are about 403 miles north-east from Campbell Island. The group consists of several detached rocks and islets, occupying a space of from four to five miles long by two miles broad. The largest island is about 1,300ft. high, and some of the cliffs rise perpendicularly for 600ft. out of the ocean. There is not much shelter for vessels, the anchorage is deep, and landing bad from the heavy roll of the ocean. Thousands of penguins, of three species (*Eudyptes pachyrhynchus*, *E. chrysocomus*, *E. filholi*), were standing as if glued to the rocks; but on our approach some rolled into the water. We steamed round the whole of the islands, sounding, and looking for castaway sailors. I did not see any seals, and Captain Fairchild informed me that he had never seen them on his previous visits. Wandering albatrosses, sooty albatrosses, molly-mawks, and Cape pigeons were hovering about, and the magellanic shag busied itself in the water. The weather was so bad that several times we had to shift our quarters, keeping steam up the whole time. At last we anchored on the south-east side, under the lee of a rock. Some of us commenced fishing, and caught quantities of a fish resembling blue cod, except in having a greenish-yellow rim round the mouth. Some were fried for dinner, but were exceedingly coarse, tasting like raw mussels. I examined some of them, and found that they were diseased, the flesh being filled with small parasites. After awhile a boat was lowered, provisions were put in for the dépôt, and the remainder of the sheep and goats that we had brought from Invercargill, and we pulled towards the shore. As we got nearer the penguins received us with their chorus of noises. Landing we found to be difficult.

The island is as hilly as the previous ones, and appears to be wholly volcanic. At an elevation of about 600ft. there is a large flat, and on each side of it a mountain. Mount Galloway, the highest, is 1,320ft. I was told by the captain that there is a fresh-water lake on the top, but I had no time to visit it. The vegetation consists of tussock-grass, with some cotton-plants, aniseed, and veronicas intermixed with it, and there is no bush whatever. The tussock-grass all grows in humps, except on the tops of the hills, where it is shorter. There is fresh water, but it is stained with guano. The birds that I observed while on shore were two species of parrakeets;

a ground-lark; the snipe (*Gallinago aucklandica*); the wandering albatross, which had just commenced to lay; the white-headed petrel (*Procellaria lessoni*), whose eggs were nearly all hatched. All round the shore the tussock was covered with the egg-shells of the penguins, which the skua gulls had carried there to devour. These birds are so rapacious that if an egg or young bird is left alone they dart down like a hawk and carry it away. I saw a half-grown penguin crawl out of its hiding-place between some rocks, when immediately two of these gulls swooped down and devoured it on the spot, one eating at the neck, the other tearing open the abdomen. The ground-lark and the two parrakeets are entirely different from any birds found on the mainland or the surrounding islands, both in size, plumage, and habits. The parrakeets are larger and plumper than the New Zealand species, the bill is shorter and thicker, the plumage is brighter, with a peculiar shimmer towards the tips of the feathers. They live in burrows in the ground, and are very difficult to shoot, as they get up almost under your feet, fly a short distance, and then run among the tussocks and hide themselves in the holes. The larger species has the whole of the plumage of the upper parts dark-green, each feather edged with lighter; top of the head and round the bill emerald-green; throat, breast, and abdomen yellowish-green; tail and wings dark-green with yellow edges; primaries indigo-blue; legs and bill bluish-grey, the latter black towards the tip and underneath; eyes red. Length from the tip of the bill to the end of the tail, 13·5in.; bill, 1·25in.; wing, 6in.; primaries, 4·3in.; tail, 4·5in.; tarsus, 1in.; middle toe, 1·35in. They were originally discovered by Captain Fairchild some years ago, when they were plentiful and tame; now they are rare and wild. The other species which I discovered is not mentioned in Buller's or Gould's books. Plumage similar to the preceding, with the exception that the emerald-green round the bill is not so conspicuous, and that the top of the forehead, a streak below the eye, and a patch on each side of the tail-coverts are brownish-red. On the back of the neck the basal half of each feather is yellow. Total length, 12·25in.; bill, 1in.; wing, 5·6in.; primaries, 4·25in.; tail, 4·5in.; tarsus, 0·9; middle toe, 1·15in. The female is smaller in size, duller in plumage, and the red is not so conspicuous. Professor Thomas, Mr. Cheeseman, and I have made a careful examination of this bird, and find that it is new to the New Zealand fauna; so I have taken the liberty of naming it *Platycercus hochstetteri*, after Arthur von Hochstetter, the son of a sincere friend from whom I received many kindnesses, and who has too soon passed away. I now exhibit a male and female of this new species. I found in their crops grass and various seeds on which they feed.

The ground-lark of the Antipodes, which was seen hopping about among the tussocks, is similar in its habits to the New Zealand species, but is smaller in size and has a different plumage. Male: Upper surface dark-brown, each feather with a light-brown edge; the outer half of the two outside tail-feathers a cream-colour; throat and breast cream-colour with a few brown streaks; abdomen light pinkish-brown; eyes dark-brown; bill and legs brown. Total length, 7·15in.; bill, 0·75in.; wings, 3·5in.; primaries, 2·75in.; tail, 2·65in.; tarsus, 0·9in.; middle toe, 1in. In the female the upper surface, wings, and tail are like the male, but lighter; throat, breast, and abdomen rusty-yellow, a few oblong brown streaks on the breast; measurements slightly smaller. Professor Thomas and Mr. Cheeseman agree with me in thinking this to be a distinct species, not yet described. I have therefore named it *Anthus steindachneri*, after Dr. Franz von Steindachner, Privy Counsellor, and Director of the Imperial Museum at Vienna, in recognition of his kindnesses to me.

The Antipodes were visited many years ago; for the second engineer of the "Stella," Mr. Bethune, picked up a piece of totara board with this inscription: "To the memory of W. Foster, chief officer of the schooner 'Prince of Denmark,' who was unfortunately drowned in the Boat Harbour, December 17, 1825."

After exchanging some of our live-stock, by taking on board fresh penguins and letting others go that we had taken from the Snares, we steamed to the Bounty Islands, distant 110 miles to the north-east. They are a cluster of thirteen rocky islets, covering a space three and a half miles long by one and a half miles broad. They are very much exposed to the surf, and landing is very bad and dangerous. No dépôt has been placed on them. I did not see any vegetation; but they are covered with millions of birds—three species of penguins, the same as on the Antipodes; two species of mollymawks (*Diomedea melanophrys* and *D. chlororhyncha*); and the dove-petrel (*Prion turtur*). All of these were breeding. The stench from the guano was dreadful, and the noise deafening. There was no space, even of a few feet, free from birds, and I have never before seen such a sight. After a short stay we left for Port Chalmers, 360 miles to the south-west. We experienced our usual rough weather, and just got into port as the wind was freshening to hurricane force.

To summarise, I may say that on the Snares there are three species of birds not found on the mainland—a bell-bird, a tomtit, and a swamp-lark; on the Auckland Islands three—a parrakeet, a snipe, and a merganser; on the Antipodes three—two parrakeets and a ground-lark. The distribution of

the sea-birds is more general, as they are often carried by storms for long distances.

My trip was a very pleasant one, but too short; for on each of the islands I could have found several months' work. Notwithstanding the interest felt in my pursuits, it was sad to me to see so many vestiges of disastrous shipwrecks. No one can say how many human beings have lost their lives there and perished in a watery grave. Most sailing-vessels bound from Australia to Europe, or *vice versâ*, pass near these islands, and the constant bad weather and dense mists render them very dangerous localities. Passengers who have just said "good-bye" to their friends at the antipodes to meet others in Europe, or those who, after a long and dreary voyage, were coming near their destination, have been awakened by a lurch or two and a sudden shock to find their vessel going rapidly to pieces in the tremendous seas. What a relief it must be to the survivors to find a dépôt where they can obtain shelter and the necessaries of life!

I am sure that you will take delight in looking through the album of beautiful views taken by Mr. Dugald, the photographer, of the chief localities visited by the "Stella." Mr. Cheeseman has kindly lent me a copy of Sir Joseph Hooker's "Flora Antarctica," which contains coloured illustrations of the plants inhabiting the islands; and I am much indebted to Mr. Cochrane for the loan from the Bishop's library of vol. vii. of Gould's "Birds of Australia," in which you will find beautiful drawings of many of the birds I have mentioned.

In conclusion, as this is my last paper, I have to thank the President and members of the Institute for the kind manner in which they have treated me during my stay in New Zealand.

ART. L.—*On the Visit of Captain Cook to Poverty Bay and Tolaga Bay.*

By Archdeacon W. L. WILLIAMS.

[Read before the Auckland Institute, 24th September, 1888.]

PLATE XXXIII.

THE interest which will always attach to the first visit of Captain Cook to the shores of New Zealand is sufficient justification for any attempt to elucidate any portion of his narrative, and, by the aid of personal acquaintance with the localities touched at, and reference to Maori traditions of the events, to enable any reader to present to his mind a more

vivid picture of all the circumstances. When, as in this case, places are not described in minute detail, it is often a matter of considerable difficulty to identify any particular spot; though this difficulty may often in a great measure be overcome by careful examination of the ground, and close attention to every hint contained in the narrative which may serve as a clue to the identification of the actual site of any occurrence. This, then, is what it is proposed to attempt in this paper with reference to Captain Cook's visit to Poverty Bay and Tolaga Bay.

It was on Friday, the 6th October, 1769, that the land was first seen from the masthead, bearing west by north, the longitude of the ship having been ascertained to be 180° 55′ W. On Saturday, the 7th October, it fell calm till the afternoon. At 5 p.m. Cook noticed a deep bay, and stood in for it, but when night came he kept plying off and on till daylight. In the morning (Sunday, 8th October) he found himself considerably to leeward of the bay, the wind being at north, and it was not till 4 o'clock in the afternoon that he anchored "on the north-west side of the bay, before the entrance to a small river, ... at about half a league from the shore."

"In the evening," Cook says, "I went on shore, accompanied by Mr. Banks and Dr. Solander, with the pinnace and yawl and a party of men. We landed abreast of the ship, on the east side of the river, which was here about forty yards broad; but, seeing some natives on the west side, whom I wished to speak with, and finding the river not fordable, I ordered the yawl in to carry us over, and left the pinnace at the entrance. When we came near the place where the people were assembled they all ran away; however, we landed, and, leaving four boys to take care of the yawl, we walked up to some huts, which were about two or three hundred yards from the water-side. When we had got some distance from the boat, four men, armed with long lances, rushed out of the woods, and, running up to attack the boat, would certainly have cut her off if the people in the pinnace had not discovered them, and called to the boys to drop down the stream. The boys instantly obeyed, but, being closely pursued by the natives, the cockswain of the pinnace, who had charge of the boats, fired a musket over their heads. At this they stopped and looked round them, but in a few minutes renewed the pursuit, brandishing their lances in a threatening manner. The cockswain then fired a second musket over their heads, but of this they took no notice, and, one of them lifting up his spear to dart it at the boat, another piece was fired, which shot him dead. When he fell the other three stood motionless for some minutes, as if petrified with astonishment. As soon as

they recovered they went back, dragging after them the dead body, which, however, they soon left, that it might not encumber their flight. At the report of the first musket we drew together, having straggled to a little distance from each other, and made the best of our way back to the boat; and, crossing the river, we soon saw the native lying dead upon the ground. Upon examining the body we found that he had been shot through the heart. . . . We returned immediately to the ship, where we could hear the people on shore talking with great earnestness, and in a very loud tone—probably about what had happened, and what should be done."

The place of landing was evidently what is now commonly called the boat-harbour, immediately on the south-east side of the mouth of the river, and separated from it by a narrow reef of rocks. From this place Cook and his companions walked about two hundred yards to a sandy point clear of the shelving rocks, as the most convenient place from which to cross over to the point formed by the junction of the Waikanae Creek with the river, where the natives were first seen, who ran away as the strangers approached them. The huts for which they were making when the attack was made upon the boat were probably not far from the north bank of the Waikanae, a short distance above the present signal-station. The four men who attacked the boat are said to have rushed out of the woods on the east side of the river. There are no woods in the neighbourhood now, nor have there been any during the last fifty years; but woods are said by the natives to have existed formerly on the hill-side, within a short distance of high-water mark, which would form a convenient hiding-place for the natives, whence they might observe the movements of the strangers without being seen themselves. The four men belonged to the Ngationeone hapu of the tribe called Teitanga-a-Hauiti, and the name of the one who was shot was Te Maro.

On Monday morning, the 9th October, a party of natives was observed at the spot at which they had been seen the previous evening, and Cook determined at once to try to open up friendly intercourse with them. Three boats were ordered, manned with seamen and marines, and with these he proceeded towards the shore. Cook, with three others, landed first from the small boat; but they had not advanced far towards the natives when the latter all started up and showed themselves to be well armed with spears and *meres*, manifesting at the same time unmistakable signs of hostility. Cook therefore determined to return at once to the boats, and to get the marines landed. This was soon done, and they marched, with a jack carried before them, to a little bank about fifty yards from the water-side. Here they were drawn up, and Cook

again advanced, with Tupaea, Messrs. Banks, Green, and Monkhouse, and Dr. Solander. Tupaea was directed to speak to the natives, and it was soon evident that he could readily make himself understood. After some parleying about twenty or thirty were induced to swim over, most of them, however, bringing their arms with them. All attempts to establish friendly intercourse were vain, as the only object the natives seemed to have in view was to get possession of the arms of the strangers, which, as they could not obtain them by barter, they tried to snatch out of their hands. What followed is best described in Cook's own words. "In a few minutes, Mr. Green happening to turn about, one of them snatched away his hanger, and, retiring to a little distance, waved it round his head with a shout of exultation. The rest now began to be extremely insolent, and we saw more coming to join them from the opposite side of the river: it was therefore become necessary to repress them, and Mr. Banks fired at the man who had taken the hanger with small shot, at the distance of about fifteen yards. When the shot struck him he ceased his cry, but, instead of returning the hanger, continued to flourish it over his head, at the same time slowly retreating to a greater distance. Mr. Monkhouse, seeing this, fired at him with ball, and he instantly dropped. Upon this, the main body, who had retired to a rock in the middle of the river on the first discharge, began to return. Two that were near to the man who had been killed ran up to the body; one seized his weapon of green talc, and the other endeavoured to secure the hanger, which Mr. Monkhouse had but just time to prevent. As all that had retired to the rock were now advancing, three of us discharged our pieces, loaded only with small shot, upon which they swam back for the shore, and we perceived, upon their landing, that two or three of them were wounded. They retired slowly up the country, and we re-embarked in our boats."

The party of natives thus encountered was not the same as that which had been seen the evening before. According to the Maori tradition, the ship had been seen coming into the bay the day before, and was thought to be a floating island; and this was a party of the Rongowhakaata tribe, who had come from Orakaiapu, a pa just below the junction of the Arai and Waipaoa Rivers, for the express purpose of trying to take possession of the ship, and hence their hostile attitude. The man who seized Mr. Green's hanger, and lost his life in consequence, was Te Rakau. The landing was effected, as before, at the boat-harbour, and the place where the marines were posted could easily be identified before the whole aspect of the place was changed by the harbour-works which are now in progress. It was a nearly level piece of ground, about one

acre in extent, from 4ft. to 8ft. above the level of high-water mark, and immediately adjoining the spot where the river was crossed on the preceding evening. A part of it may still be recognised between the outer end of the block-yard of the harbour-works and the base of the hill. The rock in the middle of the river which the natives used as a resting-place is known by the natives as Toka-a-Taiau, and, from the way in which it is spoken of by Cook, would seem to have stood higher at that time than it has done now for many years past, and perhaps to have been awash, if not dry, at low water. Till within the last few years its position was always indicated at low water by the rippling of the current, but since it has been partially blasted away with dynamite it has not been so easy to detect it.

Having failed, as above related, to establish any sort of friendly intercourse with the people, Cook proceeded, with his three boats, to examine the bay in search of fresh water, and also with the design, if possible, of surprising some of the natives and getting them on board his ship, that by kind treatment their friendship might be secured, and that by their means an amicable correspondence might be established with their countrymen. Two canoes were seen coming in from the sea, making apparently for the mouth of the Kopututea River, which was then situated much nearer the Turanganui than it is now, and somewhere near where it is shown in the accompanying map (Pl. XXXIII.). One of these canoes was intercepted, but on the approach of the boats the crew, seven in number, began the attack so vigorously with their paddles, with stones, and with other weapons, that the order was given to fire upon them, when four were, unhappily, killed. The other three, who were all young lads, immediately leaped into the water, but were soon captured and taken on board the ship. Their names were Te Haurangi, Ikirangi, and Marukauiti.* The kind attentions of their captors soon allayed their fears, and they became very sociable, asking and answering many questions with great appearance of pleasure and curiosity. On the following morning (Tuesday, 10th October) they were told, to their great delight, that they were to be put on shore again, but it was not without considerable reluctance that they consented to be left at the place where the boats had landed the day before. An officer and a party of men had already been sent on shore to that spot to cut wood, and Cook afterwards landed at the same place, with the three boys, Mr. Banks,

* Cook writes the names thus: "Taahourange, Koikerange, and Maragovetts." The descendants of Ikirangi and Marukauiti still talk of the intercourse which their ancestors held with "Tepaea," but the name of Te Haurangi is forgotten.

Dr. Solander, and Tupaea. When they had crossed the river, the boys, after some hesitation, took their leave. Cook and his other companions then crossed the Waikanae at the old ford, a short distance from the mouth, and strolled up the right, or seaward, bank of the creek, hoping to be able to shoot some ducks, four marines being directed to keep abreast of them on the sandy ridge between the creek and the sea, to guard against surprise. After they had advanced about a mile a large body of natives was seen coming rapidly towards them, whereupon they drew together, took to the beach, and hurried back to the boats, the three boys joining them again and claiming their protection. As soon as they had got safely across the river, the natives, all armed, to the number of about two hundred, followed them across the Waikanae to the point. The boys, recognising the body of Te Rakau, which still lay exposed on the beach, went to it, and covered it with some of the clothes which had been given them. Soon after this a single man, unarmed, who proved to be the uncle of Marukauiti, swam over to them, bringing in his hand a green branch, which was taken to be an emblem of peace. After making him a few presents, they left him and returned to the ship, the boys accompanying them. The actions of the natives were closely watched from on board the ship. The man who had swum across to them was seen to perform some peculiar ceremonies over the dead body of Te Rakau, which was afterwards fetched across the river, and carried away on a litter. The boys were landed again in the afternoon, and were seen to go away with the main body, as they returned by the way by which they had come. The Maori tradition states that Ikirangi and his companions had been out fishing, and that in answer to Tupaea's questions they had told him that the *ariki*, or principal chief of the district, was Te Ratu. This man was chief of the Rongowhakaata tribe, and must have possessed great influence; for afterwards, when coasting along the Bay of Plenty, Cook says, "As far as we had yet coasted this country, from Cape Turnagain, the people acknowledged one chief, whom they called Te Ratu, and to whose residence they pointed in a direction that we thought to be very far inland, but afterwards found to be otherwise." There are no direct descendants of Te Ratu now living, but the family is represented by the descendants of his brothers. The Maori tradition also mentions a red garment as having been laid upon the body of Te Rakau, to which they gave the name of Te Hinu o Tuhura.

"The next morning," Cook says, "Wednesday, 11th, at six o'clock, we weighed and stood away from this unfortunate and inhospitable place, to which I gave the name of Poverty Bay, and which by the natives is called Te Oneroa, or Long

Sand, as it did not afford us a single article that we wanted, except a little wood. . . . The south-west point of the bay I named Young Nick's Head, after Nicholas Young, the boy who first saw the land." Thus ended Cook's only visit to this part of New Zealand; but as the ship lay becalmed in the afternoon, a little to the south of Young Nick's Head, several canoes put off, and one, which had followed the ship out of Poverty Bay, came directly alongside. With a little persuasion the four men who formed the crew (one of whom was recognised as one of the hostile party encountered on the Monday) were induced to come on board the ship. Their example was shortly afterwards followed by the rest, and there were soon around the ship no less than seven canoes and about fifty men. About an hour before sunset the canoes all moved off, but three of the men were left on board, and were transshipped on the following morning to a canoe off Table Cape.

After this Cook continued his voyage southward, following the coast as far as Cape Turnagain, whence he returned on the 17th October, with the view of examining the coast to the northward of Poverty Bay. On Friday, the 20th, being prevented by the wind from fetching Tolaga Bay, he anchored about 11 o'clock in another bay, a little to the north, the name given to which by the natives, he says, was Tegado. What Maori name this represents I have been unable to discover. He gives no description by which the bay may be identified, but from Parkinson's journal it is clear that it was Anaura.* The people were all remarkably friendly, and were found to be acquainted with what had happened at Poverty Bay less than a fortnight before. On the 21st Lieutenant Gore, with a strong party of men, obtained a supply of fresh water, and Mr. Banks and Dr. Solander found many new plants, and shot a few birds.

On Sunday, the 22nd, another start was made, but, the wind being unfavourable for standing to the northward, Cook determined to put into Tolaga Bay (Pl. XXXIII.), some natives having told him of a small cove, a little within the south point of the bay, where fresh water was handy, and where the boats might land without being exposed to a heavy surf. This is the cove which in recent times has always borne the illustrious navigator's name. The natives here were as friendly as those at Tokomaru, and a good supply of wood and water was easily procured. During the eight days' stay at this place

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* "On the 21st we anchored in a very indifferent harbour, in 8½ fathoms of water, about one mile and a half from the shore, having an island on the left hand, which somewhat sheltered us" (Parkinson, quoted by Mr. Colenso, "Trans.," vol. x., p. 123). It will be noticed that there is a discrepancy in the date; but throughout this portion of the narrative Parkinson's dates are one day in advance of those given by Cook.

Mr. Banks and Dr. Solander explored the neighbourhood, and were rewarded by the discovery of many more plants new to science. In the course of their rambles they came upon what is described as a very extraordinary natural curiosity. "It was a rock, perforated through its whole substance so as to form a rude but stupendous arch or cavern, opening directly to the sea. This aperture was seventy-five feet long, twenty-seven broad, and five-and-forty high, commanding a view of the bay and of the hills on the other side, which were seen through it, and, opening at once upon the view, produced an effect far superior to any of the contrivances of art."

There are three small streams of water here, one of which finds its way to the sea through the natural arch above described. The arch (called by the natives "Te Kotore o te Whenua") pierces the ridge the extremity of which forms the western head of the cove, and is about 400yds. from high-water mark within the cove. The measurements given by Cook do not quite correspond with the present dimensions. The present length is 55ft., the breadth at the narrowest part 24ft. 6in., and the height at the lowest part 23ft. The length has probably been reduced by the falling-away of the cliff at the outer end, at which part also the measurements of the height and breadth given by Cook may have been estimated.

About 30yds. from high-water mark, among some bushes about 20ft. up the side of the same hill as that in which the arch occurs, is what is known as "Cook's well." This is a small hole, about 10in. in diameter and about 1ft. deep, excavated in the soft rock where a tiny rill trickles down from a small spring a little higher up the hill. This could not have been used in any way for watering the ship, but was probably hollowed out for amusement by some of the boys in the ship's company. That it is not a natural cavity, but that it was made on the occasion of Cook's visit, seems to be satisfactorily shown by the name which the natives have given to it—viz., "Te Wai Keri a Tepaea," or Tepaea's Well; Tepaea (in which form they have preserved the name of the Tahitian Tupaea) having been thought by them to have been the name of Captain Cook. Various letters have been cut near the little well, but most of them have become very indistinct from the scaling-off of the surface of the rock. It is impossible to assign any date to these, which may all of them be much more modern than 1769.

Maori tradition states that Hinematioro, who was then a young girl, was pointed out to Cook as a young lady of high rank, and that he presented her with beads and other ornaments. Hinematioro was much looked up to in her time by all the tribes along this part of the coast, and her name was known formerly as far north as the Bay of Islands as that of

a great *rangatira*. She lost her life about sixty or seventy years ago when making her escape from Te Pourewa, or Sporing's Island, the pa on which was attacked by Ngatiporou. The canoe was making for Whangara, and was upset at sea, the only survivor being her grandson, the late Te Kani-a-Takirau.

Cook says that the bay is called by the natives "Tolaga;" but this has not been identified with any Maori name now in use in the neighbourhood. The bay takes its name from the River Uawa, which flows into it; and the name of Cook's cove is Opoutama. The rocks off the entrance to the cove have altered very little since Cook's time, for the description which he gives of them might have been written yesterday. "Close to the north end of the island [Sporing's Island], at the entrance into the bay, are two high rocks: one is round, like a corn-stack; but the other is long and perforated in several places, so that the openings appear like the arches of a bridge. Within these rocks is the cove where we cut wood and filled our water-casks."

On Monday, the 30th October, Cook made sail again to the northward, and here we take our leave of him.

ART. LI.—*On the Relics of Captain Cook's Last Voyage.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute, 14th Oct., 1888.*]

ABOUT eighteen months back an account was given in the *Illustrated London News* or *Graphic* of the discovery of a walled-in cupboard, containing a number of curiosities of savage life, and said to be labelled as from New Zealand in the handwriting of Sir Joseph Banks. These were afterwards purchased for an Australian museum—I think, that of South Australia. The bulk of these were recurved fighting-clubs from the Pacific Islands, and not from New Zealand. But, if I remember aright, there were a few stone *meres* in the collection; and what specially took my attention was an oval wooden bowl, described as used to catch human blood at the cannibal feasts.

About the year 1855 I found the exact counterpart of this same bowl on the Canterbury Plains, about two miles from what is now the Township of Oxford. It was face downward in the short tussock-grass, and, as I viewed it, end-on, it had just the appearance of a cannon-ball half imbedded in the soil. I was extremely astonished, and, on

taking it up, found it to be hollow, and that it had a rat's nest of dry grass underneath. We had no museums in those days, and, as I was living in a tent at the time, and leading the rough life of a pioneer, the bowl was not properly taken care of. It was of oval shape, about 18in. long, by 12in. wide and 8in. deep, roundish at the base, and had at the top edge of one end a slight hollow scooped out, and an extension, or lip, projecting therefrom ½in. beyond its surroundings, evidently as a convenience to pour from. The wood of the bowl was about 1½in. thick, and in a fair state of preservation. Here we have good evidence that the bowl in the Cook collection was of New Zealand origin. But I think it should be notified to those who purchased the aforesaid collection that the bulk of the curios were not from New Zealand.

I append an extract from an English paper, which shows the burial-place of one of Captain Cook's crew, who sailed with him during his last voyage. The extract is as follows:—

"Gainsborough Gossip.

"By Gauntlet.

"One of the oldest inhabitants kindly guided me through the parish churchyard recently, and pointed out several items, some of which I jotted down for reference in this column, in the hope that they might prove interesting to my readers. . . . Another monument was sacred to the memory of Richard Rollett, formerly master sailmaker of H.M.S. The Resolution, Captain Jas. Cook, in her second voyage round the world; died the 20th day of January, 1814, aged seventy-four years. The 'Resolution' arrived at Sheerness, with her sister-ship the 'Discovery,' on the 14th October, 1780, Captain Cook having been killed by the savages at Owyhee in the February of the previous year. My loquacious and erudite guide informed me that Mr. John Nettleship, who formerly kept the Friendship Inn, married one of Mr. Rollett's daughters."

Art. LII.—*Snow Scenes on the Southern Alps.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute, 15th Oct., 1888.*]

I will first give an account of how my brother, John White, and C. C. Garrett were caught in an avalanche, and returned home one day hatless and without their long climbing-sticks. They started at grey dawn, in winter time, to climb one of the big ranges of the Eyre Mountains, situated on the south-west

side of that immense inland lake Wakatipu, their object being the rescue of any sheep which might have been snowed in.

These ranges, along the top, as seen in summer, are mostly run out as narrow as the ridge of a house, the topmost points being more or less perpendicular, and consisting of a yellowish-grey rock, sometimes covered by a minute lichen of a red colour, which will make the rock look a bright red when viewed from a distance; in more accessible places the ranges are rounded, and covered with broken fragments like road-metal, all of corresponding size—in one area large, in another place all much smaller, but always of uniform size. The very steep places seldom hold the snow long, owing to the action of the wind and sun. As a rule it is impossible to travel along the actual ridge, but here and there are places which will allow a passage to the other side of the range.

To return to my story: The two were travelling along, one behind the other, changing places occasionally by the leader falling to the rear, which is requisite in snow-travelling, as the person in advance has the most fatiguing work in breaking down the snow, and so it is advisable to relieve one another in this way. They were near the mountain-top, and moving parallel to the summit, when a crackling noise was heard passing along above them, and almost immediately the surrounding snow, with them on top, commenced to slide downwards, leaving the ground above quite clear from snow. Presently the surface of the moving snow began to undulate and mix up, great newly-made snowballs suddenly consolidating as they rushed down over the surface. They were then knocked down and covered up in darkness, but could feel from painful abrasions that the course was still downward, and lively apprehensions were entertained lest they should be carried over some precipice. Luckily this did not occur. My brother was the first to force a way out from under the snow, and looked about anxiously for his companion. Soon a portion of the snow was seen to be violently agitated, and arms and legs appeared, presently followed by their owner. They were more or less sprained and bruised by rough treatment, and caps and sticks were lost; so they came home with heads tied up in pocket-handkerchiefs, and looked as if they had been engaged in a free fight.

Another avalanche occurred in this manner: I was in chase of some thirty sheep, which were endeavouring to circumvent me by climbing upwards to some steep rocks from which the snow had blown away, and which so looked inviting at a distance, but, of course, were too steep for even a sheep to travel on. I sent my dog after them to head the mob down. He overtook them just below the rocks, turned them, and then I was amazed to see him, with legs stretched out, spinning round and

round in the same place, with the sheep standing below him. Presently the dog ran off upwards, and I then saw the reason of his strange efforts to escape, for the snow had evidently been in the act of parting where the dog had been. Then a great sheet of snow began sliding down, carrying the sheep with it, and shooting into a narrow channel leading down the mountain abreast of the spur on which I stood. On entering the gully the snow began to break up, and at times all the sheep were buried from sight, then several bodies would pop out, disappearing again like porpoises playing at sea, others appearing and disappearing as the whole mass rushed down hill. When the snow came to a stop the sheep commenced to force a way out and shake themselves, and I believe every one came out all right. Of course these sheep were merinos, and so good climbers and very active.

A most wonderful sight was the remains of a very large avalanche at the shady side of Mount Nicholas. I saw it after the bulk of the winter's snow had thawed in the spring on the sunny slopes. Travelling round the back, along the foot of the mountain, which is detached from the main range by small valleys, I came to a large gully which descended the mountain-side. This was at the foot filled up with gigantic snowballs, one on top of another, 30ft. or 40ft. deep, some 6ft. through, others not less than 3ft., all circular, very hard, and distinct one from the other. I went across, stepping from each one as if they had been large boulders, and could hear the water of the creek rushing under them, deep down underneath.

One very severe winter, which was commenced by the most terrible thunderstorm with heavy rain, the thunder being almost continuous, aided by the echoes and vibrations along the mountain-sides, it seemed during the darkness of the night as if half the mountain-sides were coming down in landslips. All this confusion of sound and fierce lightning caused the merino sheep to make upwards through the melting snow left from a previous storm, it being the natural instinct of the mountain-bred sheep to hurry upward when in danger or fear. Consequently, when the heavy rain was succeeded by an unusually heavy fall of snow, several large mobs of sheep which were collected together on the upper parts of the range became completely blocked in by the snow. They by trampling consolidated the snow under foot to a thin sheet of ice, and so made an enclosure with solid walls of snow some 8ft. high. One large mob of about fifteen hundred were trapped in this way at the head-waters of the Afton Creek, on the south-west side of Lake Wakatipu. The snow, being in the form of dry crystal cubes, had no adhesion on the surface, so the cold dry winds which succeeded the storm blew

it in cutting drifts against the outermost sheep, causing them to crush and trample underfoot some five hundred of their number. The dead became frozen and hermetically sealed up in the icy floor. On the accident becoming known an attempt was made to drive the survivors over the top of the range to the sunny side; but the summit rocks proved to be perpendicular, and, the snow giving way on their steep face, about ninety of the leading sheep were precipitated over the cliffs on the opposite side, and killed. After this it was found necessary for all hands—five of us—to climb up the mountain through the snow for five successive days, and, it being useless to attempt shovelling the loose snow, all were employed treading it hard to a width of 18in., forming a solid track along the mountain-side for fully a mile and a half, towards the termination of the range. Here it was almost free from snow owing to its facing the sun. On the sixth day the sheep were coaxed along this line in single file, and so taken out to the clear grass. Here and there one would leave the track and become buried in the snow, requiring to be searched for, pulled out, and the snow adhering to its head scraped away from over the eyes, and started again on the track. A few suffered from snow-blindness.

A man undertook to skin the dead sheep during the ensuing summer, and used to dig the bodies out with a pick, then roll them down the hill and allow a few days for them to thaw out. They remained fresh quite into the autumn.

Two or three sheep snowed in are found by seeing a small round hole in the snow, about 3in. in diameter, and having the edges discoloured. On breaking down the snow the sheep are seen in a small circular dome-shaped hollow. If the frost has hardened the snow-surface, on lifting them out they scamper off, having been shut up without food for possibly a fortnight. I never noticed instances of their eating each other's wool, as is said in books to be the case, but have seen the wool thick on the ground, having been frozen tight when the sheep were lying down, and so pulled out in locks on the sheep rising. This might give the impression that the sheep had pulled it to eat, to persons who did not observe closely.

Sheep are difficult to see on the snow at a distance, owing to their carrying a coating of snow or frost on the tips of the wool, and sometimes having long icicles attached to their sides. The discoloured tracks made for short distances back and across the limit of their snow-yard is what mostly leads to their discovery from any distance.

Art. LIII.—*Notes on Coloured Sheep.*

By Taylor White.

[*Read before the Hawke's Bay Philosophical Institute, 11th Sept., 1888.*]

The heading of this paper approximates very closely to what I may call "shop;" but, as the animals chiefly mentioned are a distinct race, and more rare and ornamental than useful, the information contained can the more readily be classed as natural-history notes. I will first give the correspondence received, and then append a few observations of my own.

"Park Lodge, Baslow, Chesterfield,
"31st May, 1888.

"Dear Taylor,—

"I have endeavoured to obtain as full particulars as possible with regard to the Duke of Devonshire's spotted and horned flock at Chatsworth. Little, however, is known of this, and it is only quite recently that the agent has endeavoured to improve the breed by importing new blood; still, the flock does not seem to have suffered badly by in-breeding, as big prices have been paid for sheep to cross with others. There seem to be a few similar flocks in the country, notably at Tabley and Canons Ashby, as you will see by enclosed copy of a letter.

"The Chatsworth sheep have mostly four horns—two upright ones on the top of the head and two curling over the face under the ears. Some ewes, I see, have only two (straight) horns. They do not let the rams run with the ewes. Their tails are not docked, on which there is seldom any wool to speak of. The sheep are kept solely for ornament: their wool is almost valueless, though I believe the mutton is considered a delicacy on account of its venison-like flavour.

"Yours very sincerely,
"W. Mervyn Wrench."

Extract.—"The Duke of Devonshire recollects the sheep being at Chatsworth as far back as 1819, and Sir Dominic Coningham called them 'Jacob's sheep.'

"They would in olden times have been called 'merino.' I enclose, however, a copy of a letter from Sir H. Dryden which seems to point definitely to the correct name as being 'Spanish.'"

"Canons Ashby, Byfield, Northamptonshire,
"28th October, 1884.

"Dear Sir,—

"I call the spotted sheep 'Spanish.' They have been for sixty years or more in this neighbourhood. I had the breed from a neighbour who had been in the Peninsular War, and he called them 'Spanish,' though I don't remember having asked him if he saw similar sheep in Spain.

"The breed has been at Tabley for nearly two hundred years, as shown by an old painting of the house at a certain date. Lord de Tabley has, I think, no special name for them but 'spotted.' The Tabley rams had straight horns—nearly all had four, and very long; but when he had a ram from me many came with the twisted horns, and Lord de Tabley complained that I had spoilt the beauty of his flock. At Tabley they kept all the rams for ornament, and never ate any of the mutton. These gentry were let live as long as they could, and amused themselves by continual fighting. I treat my flock as other flocks are treated, and have no other mutton.

"An officer told me he had seen such in the Basque Provinces, and there are many in Shetland more or less spotted, and Shetland has great trade with Spain. The Shetland people don't like the *spotted* ones, so the marking is not distinct, not being desired—that is, the spotted ones are got rid of.

"The size of the Tabley horns has *much* decreased—from, I suppose, breeding in-and-in. Many years ago a Spanish beggar-woman came here carrying a child on her back. I told her I could not speak Spanish; but she said, 'There are many of my countrymen here.' I made out that it was the *sheep*, and she explained that when the child saw the sheep it cried out that it recognised countrymen. I asked her more, and she said there were numbers of them where she lived; but I forget what part of Spain. The merino sheep are *totally distinct*.

"We have had some curious facts in breeding. When Lord de Tabley had a *curly-horned* ram from here, the rams had curly horns almost exclusively; when, by an accident, our spotted rams got to white ewes, the lambs were *all black;* when a white tup has got to our spotted ewes, the lambs were *all white* and *very* white. I always kill any crossbred lambs, so I can't say what their progeny would be.

"You may observe that the black wool is harsher and more curly than the white on the same sheep. This, years ago, made our wool less valuable than the white, but now the buyers make no difference, and I believe for some Scotch manufactures the mixture is liked, as it makes an undyed brown.

"Early in summer I always observe that the spots of black are below the level of the white ground. It is odd that I have never seen a black ground with white spots, except sometimes a white *cap*, never on the *body*.

"Yours faithfully,

"H. DRYDEN.

"Our sheep average about 56lb., and some wethers go up to 75lb."

From this the Duke of Devonshire's and Lord de Tabley's sheep appear identical—white spotted with black; two straight or slightly-curved upright horns, and two smaller horns bent back round the ears and pointed under them to the front; wool scant and inferior; known to have been at Tabley two hundred years.

Sir H. Dryden's sheep, with similar markings, but probably with only one pair of horns, twisted spirally as in the merino; wool of fair quantity and quality; in the neighbourhood of Canons Ashby over sixty years.

In the zoological collection at the Royal Park, Melbourne, some fifteen years ago, I saw a ewe having short dark shining red hair, having drooping ears and no horns, also a larger sheep with long brick-coloured wool, which I supposed to be a son of the ewe by a white-woolled ram; probably Chinese.

In England, the late celebrated novelist, Mayne Reid, had a flock which he describes as black with white face and white tip to the tail, without horns, which he called Jacob's sheep. He got the originals from a travelling mob, and had no knowledge where they were bred. He tried one season to show as a curiosity at the Royal Agricultural Show, but was not allowed, as "they were not a known breed." Afterwards he, being indignant at their rejection, wrote a letter to the *Times* about them. A supposed portrait of one was given in the *Live-stock Journal*, but it was coloured in black and white patches. They were said to breed true.

"*Shetland Sheep.*—At the last Royal Agricultural Show was a pen of five miniature ewes of jet-black colour, which were a great attraction to the visitors."—*Live-stock Journal.*

Darwin, in "Variation of Animals and Plants under Domestication," speaks of a famous breed of black sheep at Karakool, Turkistan, with a valuable fleece of lustrous black wool. The wool was said to deteriorate when the animals were removed elsewhere.*

Dr. Randal, in "American Sheep Husbandry," in describing the early attempts to introduce the merino sheep from Spain to America, says, "The several small lots first imported were allowed to die out, not being fancied at that time; but the very first, which with difficulty were obtained through the influence of the American Ambassador to Spain, when they arrived in 1808, were all black." I think five or seven were the number landed. This was either a swindle in picking a few black sheep from a white flock, or indicated a black merino flock existing at that time.

It is very remarkable that writers, in trying to trace the origin of the merino sheep, always imagine them to be of

* See "Travels in Bokhara," by Sir A. Burnes.

English origin, for they are prevented from looking to North Africa owing to the heat of the climate causing sheep in that country to have a covering of hair; otherwise it would be supposed the Moors introduced them from Barbary.

On the other hand, these spotted sheep; the Herdwicks, on the Cumberland fells, with curled horns; the Cheviots, on the Border Hills, a polled race; and the sheep of the Shetlands, of very diminutive size, are all supposed to come from Spain, the popular tradition being that they are survivors from the wreck of the Spanish Armada, in the time of Queen Elizabeth. That crews from one or more of these vessels escaped to the Shetlands there seems to be good evidence; also, that these shipwrecked people taught the natives, with whom they intermarried, a particular secret in the art of weaving and dyeing woollen goods, which I believe is a speciality to this day.

Quoting from the "Technical Educator:" "Beautiful black lamb-skins are imported from the Crimea, and still more rich and glossy, with a short fur, from Astracan."

Most people are under the belief that flocks of sheep are necessarily white, but no doubt, if the matter were properly investigated, a number of pure breeds of coloured sheep would be found inhabiting out-of-the-way places.

Youatt says, "There is reason to believe that sheep in their early domesticated condition were brown or dingy black: during the classical period the sheep of Spain are described by several ancient authors as being black, red, or tawny."

Darwin remarks, "In the Tarentino the inhabitants keep black sheep alone, because the *Hypericum crispum* abounds there, and this plant does not injure the black sheep, but kills the white ones in about a fortnight's time."

"A so-called Spanish ram, which had two small black spots on the sides, when mated with seven Southdown ewes, produced thirteen lambs all perfectly black."—Mr. Wilmot, "Quarterly Review," 1849.

"The Rev. W. Darwin Fox believes that this ram belonged to a breed which he has himself kept, and which is always spotted black and white, and he finds that Leicester sheep crossed by rams of this breed always produced black lambs. He has recrossed these crossed sheep with pure white Leicesters during three successive generations, but always with the same result. Mr. Fox was told by the friend from whom the spotted breed was procured, that he likewise had gone on for six or seven generations crossing with white sheep, but still black lambs were invariably produced."—"Variation of Animals and Plants under Domestication."

Returning to the spotted sheep: On breeding the Tabley and Canons Ashby sheep together, a change in the character of the horns is mentioned, but the colour of the wool seems

not to have altered, as it did when crossed with other breeds: this would lead to a supposition of affinity between the two flocks.

These spotted sheep have probably lived in the parks of Tabley and Chatsworth for a number of generations, and I see no reason why they should not be descendants of the original sheep of Britain.

The Chillingham and Hamilton cattle, one a white horned and the other a white polled race, are considered to be the remnant of the herds which used to roam the forests of Britain.

Both the cattle and sheep have been kept in parks belonging to wealthy families, and been handed down from generation to generation as special heirlooms or adjuncts of the parks, and so have been preserved to the present day. Therefore I see no reason why these sheep should not be the original unimproved British sheep. It is unreasonable to always look to other countries for the origin of our different breeds of British sheep.

Art. LIV.—*Notes on the Waikato River Basins.*

By L. Cussen.

[*Read before the Auckland Institute, 17th December, 1888.*]

Plates XXXIV. and XXXV.

The Waikato River seems to have been subject to apparently abnormal changes in its course from an early period in its history. Incidental reference to these changes is to be found in several of the works on the geology and physiography of the country, but, so far as I know, the subject has never been dealt with in a comprehensive manner. At each change the river would appear to have left its natural valley, and, turning westward, to have found a new course through high mountainous country which separates one basin from the other. Thus it appears to have worked in a diagonal line across the country, from east to west, crossing three primary river-valleys. In consequence of these facts, the physiographical history of the basins, regarded as a description of the surface-configuration of the Waikato Valley due to a combination of the effects of volcanic action and planetary denudation, is of more than ordinary interest.

Unlike many of the large questions which geologists have to deal with, the study of the earth's surface-features is within the limits of our most familiar experiences, and requires no special scientific knowledge for its understanding. The plain

book of nature is laid open before us. In its most legible pages we may read—on the faces of the cliffs and on the terraces, in the steep or gentle slope of the valley towards the river, and in the character and condition of the soil—the half-hidden history of the past.

For years past my duties took me into every part of the Waikato's basins from its source to the sea, and I had an excellent opportunity to study its topography.

These notes refer to a comparatively recent period, when the surface-configuration of the country was very much as we find it now, and not to the geological ages of the past, during which the country rose gradually out of the sea and our river-valleys were first formed. Only the salient points of the subject can be touched in a short paper. The changes in the course of the Waikato seem to have been four in number, a long space of time intervening between each of them. The first took place at the Wai-o-tapu Valley, twenty miles below Taupo. The Wai-o-tapu has evidently been a large river-valley. It is, in fact, a continuation of that above, through which the Waikato River takes its course from Taupo. The direction and configuration of the valley lead to the conclusion that the Waikato River once flowed through it to the sea. From some cause its course was impeded: the waters were thrown back into the valleys above, which they occupied in the form of a serpentine lake or a lake-like river, with many arms spreading in between the spurs of the ranges. Round Tuahu, Ngautuku, and other hills between Atiamuri and Taupo, may be seen the old lake-beds filled up with alluvial deposits. In the valleys between the hills immense beds of pumice and sand, sometimes 200ft. in depth, are seen in level plains through which the streams have worn their channels deep down to the bed-rock, disclosing stratified layers of drift, pumice, and light sands, enclosing the trunks of trees and carbonised wood. The worn, shore-like sides which surround these pumice-beds, cliffs of tufaceous rock often plainly water-worn, and the stratified character of the deposit, leave but little doubt that a large area in this part of the Waikato Valley was occupied by a lake. The waters found their next outlet through the ranges between Whakamaru and Titiraupenga.

The elevation of the outlet was at first about 300ft. above the present bed: gradually it was worn deeper through the barriers, and the waters of the lake drained off, each successive stage in the process of lowering being indicated by a well-marked regular terrace round the south end of the gorge and the lake-basins in the valley above. These terraces are of immense proportions, and range fully 200ft. above the present river-bed.

In the valley of the Waikato, near Atiamuri, where the Rotorua and Taupo Road crosses the river, a most excellent example of the terrace-formation, and of the wonderful power of the river in denuding its valley, may be seen. The height of the Waikato is 1,200ft. above the sea at its exit from Taupo Lake, where its outflow is 16,300 gallons per second—that is to say, about 3,500 tons of water passes through its channel every minute; it has therefore as much energy to expend in denudation as would be required to lift this mass of water 1,200ft. above the sea. Naturally, in its highest reaches, where the gradients are steepest, most of the dynamic forces are expended, and therefore here are shown the greatest examples of surface-denudation.

There are evidences that the upper portion at least of the Patetere Valley, including the Tokoroa Plains, was once occupied by a lake. The stratified pumice-beds and the remains of horizontal terraces which are to be seen there indicate this. It may be that the Waikato River for a time flowed into the Patetêre by the Mangaharakeke Valley, to the eastward of the Whakamaru Range; but of this there is not sufficient evidence. We have no well-defined river-bed which the Waikato might occupy, and I think it more than probable that the Tokoroa Lake was not formed by the Waikato River. I may here mention a somewhat strange tradition which was mentioned to me by the Assistant Surveyor-General as having been related to him by Mr. Lawry: That the Waikato River formerly ran into the sea near Tauranga; and that in the course of ages it changed its course and ran out into the Hauraki Gulf; and then, again, after a further lapse of time, it ran across by Tuakau and Mauku, and then into the Manukau Harbour; and thence into the sea at the mouth of the Wairoa River. It is strange what could give rise to this tradition. I do not think the Maoris are speculative in their deductions, and they would be unlikely to draw conclusions of this kind without something more than the surface-configuration of the land to guide them. However, it is not at all probable that the Waikato River flowed through Tokoroa. The lake owed its origin to other causes, and was drained by the Waikato River through the Kopokorahi Stream.

The whole surface-configuration of the Patetere Valley bears evidence of the immense effects of sub-aerial denudation. Tokoroa Plain is 1,220ft. above the sea; the fall from there to Matamata is pretty regular, and amounts to 1,050ft., being at the rate of about 26ft. to the mile: it is easy to imagine what the effects of denudation would be in a country with such an incline, and covered with loose materials, as we find the Patetere was. These effects are shown in the many deep water-courses which furrow the valleys for miles. Most of these are

now dry. They are bordered with high water-worn cliffs of tufa, showing that they were once the beds of powerful streams. Two of the principal streams of the Patetere flow into the Waikato; the others, following the natural slope of the valley, find their way to the Hauraki Gulf.

The next remarkable change in the course of the Waikato, and that which was attended by the most serious results in the great middle basin, is that which took place at Piarere, about fourteen miles above Cambridge. Any one travelling the road from Cambridge to Oxford could scarcely fail to remark the well-defined broad valley, bordered by steep cliffs, which runs in a north-east direction by Hinuera towards Matamata. There is little doubt that the Waikato River once flowed down this naturally-sloping valley, and thence to the sea at the Hauraki Gulf. But from some cause it again left its old bed, and, turning to the westward, passed through the gorge between Maungatautari and Hinuera Ranges for six miles, and debouched into the great middle basin at Cambridge. Here, again, we have the same sequence of events recorded that took place at Whakamaru—the river formed a sinuous lake in the valleys above, extending backwards for a distance of eight miles, and covering the Waipa Plains, which were evidently the bed of a lake. We find the remains of a deep alluvial deposit, chiefly of light pumice-sands, which filled the valleys running in between the spurs in level plains. Through these, again, the streams in wearing out their deep channels exposed the strata of river-gravel, pumice-sand, and detritus, including large trunks of trees. This deposit fills the valley at Paeroa, where the Auckland Agricultural Company's homestead at Cranston is situated: it runs into the valleys between the ridges, varying in depth from 120ft. downwards. Following down the old river-bed towards Matamata, the deposit thins out like a wedge, and finally almost disappears four or five miles from the present river-bed.

The river, in working its channel deeper through the barriers in the Maungatautari Gorge, gradually drained off the waters of the lake, leaving behind, in the valley above, eight rows of terraces, which fringe the river on either side, indicating each a different stage in the lowering of the bed.

The height of the land through the gorge which the river now traversed was certainly over 200ft. above the present river-bed, and through this to the bed-rock the river has eroded its channel. We have now arrived at an area in the Waikato's basins where the facts to be recorded are of a perplexing and recondite character. The broad plain in central Waikato known as the "Waikato middle basin" has an area of five hundred square miles. We find an alluvial deposit all over the lower areas of this valley: in places it is 150ft. in depth. The

character of this deposit is unmistakable, as seen in the "washed-out" gullies so numerous all over the valley: the deposit is clearly stratified; it is made up mainly of rounded particles of pumice, interstratified with layers of clay and rhyolite sands, and enclosing the trunks of trees placed horizontally. That these deposits were brought down by the Waikato River seems unquestionable—pumice-drifts are not found in the valleys of any other rivers which flow into the Waikato middle basin; but how they came to be laid as we now find them is, in my opinion, the most interesting physiographical question which we have to deal with. Reference to the map (Pl. XXXIV.) will show the surface-height of the land at Cambridge to be 220ft. above the sea; at Hamilton it is 120ft.; at Ngaroto, 125ft.; at Morrinsville, 82ft.; and at Taupiri only 39ft. Now, we find the alluvial deposits have been carried by the Waikato waters to the Rotorangi swamps, eight miles almost in a southerly direction from Cambridge, whilst the natural fall of the country is in the direction of Taupiri, and over 7ft. to the mile. Dr. Hochstetter says of the middle basin: "The geological features of the basin are these: The lowest bed consists of layers of clay and sand, with bituminous shale, which, in some places, encloses trunks of trees changed to lignite; the shale passes into argillaceous shale, containing numerous fossil plants; these and similar strata point to the fact that the whole middle Waikato basin was but recently a shallow bay of the sea, at the bottom and on the margin of which these layers were formed."

If this be so, as the land rose and the sea receded a channel or channels would be left in the estuary, and through these channels the rivers and streams of the valley would naturally continue to flow into the Hauraki Gulf. We find, however, the places where the old estuarine channels might have been are filled with the fluviatile deposits, placed in such stratified form that they could only have been laid down by the action of very slowly-moving water in a lake or the sea. The depths of these deposits vary considerably: in the Rukuhia Swamp, between Hamilton and Ohaupo, they are from 50ft. to 70ft.; in the Piako Swamp, from 40ft. to 60ft.; at Hamilton, from 40ft. to 70ft.; and in the neighbourhood of Taupiri, the lowest point in the basin, it is a remarkable fact that the deposit is lightest. Beneath these deposits in several parts of the valley the ancient land-surface can be seen. In the Waikato River, near Hamilton, are standing several trunks of maire trees, which appear to be standing as they grew. In several of the "washed-out" gullies the same may be observed—the trunks of trees lying horizontally and some standing erect on the old surface.

The most interesting example of this character, because

of the most recent occurrence, is that shown on Mr. E. B. Walker's property at Mona Vale, four miles south-west from Cambridge (Pl. XXXV.). A drain was cut about a mile in length through a neck of dry land, to drain the Mona Vale Swamp into a dry gully which led to the Waikato River. During a heavy flood some years ago a scour was started in this drain, which soon formed a gully from 60ft. to 70ft. in depth and in some places several chains across. At the bottom of this gully the ancient land-surface was exposed to view. It consists of a stiff, brown, marly-looking soil, apparently of excellent quality. The trunks of many trees are lying on the old land-surface, and some were found to be standing, with their roots penetrating the old soil, as they grew. The present land-surface is perfectly level, whilst the ancient surface is found at various depths from 30ft. to 60ft., showing the old contour of the land. The timber found here seemed in tolerably good preservation. This is suggestive of a very interesting thought: that, if the country was inhabited previous to this submergence, some relics of the animals or men who lived in it might come to light some day on the old land-surface.

Characteristic of the middle Waikato basin are the numerous funnel-shaped holes to be seen everywhere throughout the alluvial deposits. They were formed by the subterranean or soil waters in passing along beneath the surface of the earth. They create small caverns, and, finally, underground streams, which draw away the loose material from the surface, and frequently form symmetrical funnel-shaped holes—the "pot-holes" of the settlers. Probably the water, being charged with carbonic acid, was thus enabled to dissolve some of the river-gravel through which it passes, and by degrees to become a small running stream.

Now, it seems very evident that these deposits in the middle Waikato basin could never have been laid in the bed of a lake nor by the waters of the Waikato at all with the levels of the land as we now find them. The lake would have four outlets—one at Morrinsville, one at Hapukohe, one at Matahura, and one at Taupiri, all 100ft. below the level of the bed of the lake in the centre; therefore the waters would not be impounded to place the deposits. Neither is the action of the sea admissible: the character of the deposits, the mode of their distribution, and the levels of the valley as they now stand, preclude this, the western side of the basin being lower than the eastern side, where the estuary would have its outlet. To local movement, or oscillation in the level of the land within the basin, it would seem we must attribute the phenomena. The Waikato, on debouching through the Maungatautari Gorge, would probably occupy

about 350 square miles of the low areas in the middle basin, in the form of a broad shallow lake dotted with numerous islands, which are now the clay hills and ridges of the valley. At that time the land to the east, north, and western sides of the basin stood higher than it now does—sufficiently so to enclose the waters of the shallow lake: then were the alluvial deposits of the valley laid down, and subsequently a tilt or oscillation in the surface-level of the valley took place, emptying the lake.

The almost direct course of the Waikato River from Cambridge to Ngaruawahia, and the absence of a wide river-valley, may be taken as indicating the rapid formation of the river-bed. In a flat alluvial valley we should naturally expect to find a winding river and a broad valley, instead of which we find that the Waikato River has cut its course almost straight in a north-westerly direction until it is stopped by the Hakarimata Ranges, along the base of which it flows in a northerly direction to Taupiri.

Mr. James Stewart, in his paper on "Evidences of Recent Change in the Elevation of the Waikato District,"* shows proof of subsidence as follows: "The proofs of subsidence we at present adduce are two. The first lies in the sunken forest in Lower Waikato: thus we find at a distance of forty-five or fifty miles from the sea the remains of an ancient forest, the trunks of whose trees are standing as they grew. They are found as snags where their roots are of a certainty far below the level of high water in the ocean." These trees, of course, could never have grown in that position.

Again, Mr. Stewart shows that the cylinders of the railway-bridge at Ngaruawahia are sunk several feet below low-water mark in the Auckland Harbour, and at this depth river-pebbles and shingle were found, indicating an ancient river-bed, which must of course have been higher than it now is to allow the river to flow to the sea. The same evidence was found in sinking the cylinders for the Hamilton railway-bridge, alluvium and river-gravel being found in a position considerably below the level of the water in the ocean.

In a section of a bore for coal at the Huntly coal-mines, large gravel was found at 94ft. below the surface, or about 60ft. below sea-level; pumice was found at 32ft. below sea-level. In the valleys of the lower basin of the Waikato trunks of large trees are to be found in positions where their roots would certainly be below sea-level. On the clay hills in the swamps near Rangiriri, water-worn blocks of pumice are to be seen deposited in little depressions and on small terraces 20ft. or 30ft. above the level of the swamps—positions to which only the

* "Trans. N.Z. Inst.," vol. viii., p. 430.

waters of the lake could take them. Underneath the trig. station at Pukeotoka, near Miranda, a large mass of boulders, rounded and water-worn, is found 200ft. above the neighbouring valley, through which the head-waters of the Maramarua River flow: these boulders evidently mark an old river-bed of a time when the country was 200ft. lower than it now is.

The facts above quoted, whilst they prove first depression and subsequent elevation of the land, do not, of course, show that either movement was partial or local. This is always most difficult to prove, although it is well known and an admitted fact that earth-movements are variable—here a depression, there an elevation; and the complicated forms of our stratified rocks very clearly show it.

The surface-configuration of the central Waikato basin, especially on its western side, would appear to show evidences of local subsidence. The spurs on the eastern side of the Hakarimata Range, looking southwards from Taupiri by Ngaruawahia, bear, I think, the appearance of a scarp along their base. It would be interesting to ascertain whether the Taupiri Gorge itself marks a line of fault; but a close examination of the strata on either side would be necessary for this purpose.

There is little doubt that the waters of the middle basin had their outlet by Hangawera-Hapuakohe Valley, and also through the Waitakaruru Valley for a time; subsequently they flowed through Matahura into Waikare Lake and the lower basin, and finally the Waikato drained them through the Taupiri Gorge. Remnants of the old lakes still remain in the lakelets, lagoons, and lake-like swamps which occupy the depressed areas in the valley, and many of them are fast drying up.

An interesting feature in the lower Waikato basin is the deep, wide valley which lies on the western side of the Hopuakohe Ranges. The Matahura and Wangamarino Rivers rise in it. Their head-waters are separated by a low saddle, one flowing to the north and west, and the other to the south. This valley did not, evidently, owe its origin to the streams which now occupy it: it was a great river-valley in the past, and possibly the course of the Waipa when the Waikato River discharged itself into the Hauraki Gulf.

There is no trace of pumice—the characteristic of the Waikato's alluvium—to be found in this valley. Its outlet was at Pukorokoro, into the Hauraki Gulf. The low saddle which separates the waters of the Maramarua from those of the Pukorokoro is not, I think, more than 60ft. above the level of the sea.

In the foregoing notes I have endeavoured to give some of the evidences of the changes which have taken place in the

Waikato basins. The cause of the changes is a physiographical question of great interest. There can be little doubt that the lakes which are seen to have occupied the lower areas in each basin successively were caused by the impounding of the waters of the river. By what was the impounding caused? It seems to me to be accounted for by either of two causes—the damming-up of the old river-bed or oscillations in the level of the land. We have ample evidence that at least a very large portion of the North Island has been submerged, and again rose above the sea. Speaking of the changes of level at the Thames Captain Hutton says, "It would thus appear that when the alluvium, full of boulders, found on top of the hill near Shortland was forming, the land was 1,000ft. lower than at present; that it then gradually rose until it was at least 100ft. higher than now; and at that time the Thames ran further north than Shortland. The land then sank 10ft. or 12ft. lower than now, and subsequently has again risen to its present level." Now, if these movements of elevation and depression were uniform throughout the island, when the land was 1,000ft. lower than it now is very little of the North Island was above the sea, only the high country in the interior, with our other high hills, appearing as islands off the coast.

Mr. Percy Smith has shown us very clearly that elevation has been the latest movement. A very clear case of an elevation of at least 15ft. is shown by him to have occurred in recent times at Miranda, in the Hauraki Gulf, and the settlers there are of opinion that the land on the flat referred to by Mr. Smith continues to rise gradually. One settler informed me that he was enabled to sink a drain 1ft. lower than he originally sank it, twelve years ago, and he feels convinced the tide does not now rise in the drain within a foot of its former height. We may now imagine the land (having sunk) again gradually and uniformly rising from the sea. The Waikato River may have occupied the bed it now does before the submergence. We should then expect its old valley to be filled with the detritus and alluvial materials. In the subsequent elevation the river might have first found its way to the sea on the east coast, through the Waiotapu Valley. As the land rose gradually and uniformly, the river would erode its bed deeper into the loose materials, and we might imagine, as the high land to the eastward came above the sea, its elevation being greater than the low valleys in the upper basins, the water to be impounded and a lake formed until such time as the river, having resumed its old course, by degrees removed the detritus which filled it, and so emptied the lake. If we still imagine the same to have occurred at Hinuera, where the second change took

place, the Waikato would for a time flow through the Hinuera Valley, but subsequently would resume its former course into the middle basin, when surface-denudation had washed the detritus from the old bed. But, as we have before seen, the events in the great middle basin cannot be accounted for without the hypothesis of local oscillation in the level of the land. On the other hand, if we can believe that gradual general elevation has been going on, and that it was accompanied by local movements on a smaller scale, it would be easy to account for the Waikato's changes. If, for instance, the axis of upheaval was along the main range in a south-east direction, from Te Aroha to Rotorua (which seems probable), with a slight anticline to the westward, we should find the Waikato first filling all its valleys as a lake, through elevation to the eastward, and the water seeking a new outlet in the lowest or weakest point in the gorges to the west.

That the movements in the earth's crust are complicated—here an upheaval, there a depression, faults, crushing, and corrugation of the rocks on the surface, the efforts of the earth's crust to adapt itself to the form of the cooling nucleus—seems to be the doctrine of our wisest geologists; but whether these movements are applicable to areas so small as those we have been describing is a matter of conjecture. Charles Darwin, whilst contemplating great events in South America, came to the conclusion that to volcanic action must be attributed the force by which mountain-chains are elevated; and that the efforts of the earth's crust and the contracting nucleus to conform themselves to one another by deforming the spheroid, counteracted by the earth's rotation acting to maintain the spheroidal form, cause most of our volcanic phenomena. Elie de Beaumont, the great apostle of secular refrigeration, defines these volcanic phenomena as "a struggle between the deformation of the spheroid by the loss of internal heat and volume, and the earth's rotation, which constantly tends to cause it to revert to the true spheroidal figure."

Mr. W. L. Green says, in his work "Vestiges of the Molten Globe," published last year, "When we find, in one short experience, that Chili and its Cordillera can be jerked up several hundred feet at one stroke, we may well be careful how we limit the magnitude of such catastrophes in all past time." It is in reference to these great changes of surface-configuration, so copiously noted elsewhere in the world, and to which sources of information New Zealand might contribute a good deal, that I hope these notes may be of some interest. If the conclusions I have drawn are not satisfactory, the simple facts recorded will still remain independently, as

links in the chain of evidence from which others may draw their own conclusions.

EXPLANATION OF PLATES XXXIV. AND XXXV.

Plate XXXIV.—Map of the Waikato River basin.
Plate XXXV.—Section of Walker's Gully.

ART. LV.—*A Local Tradition of Raukawa, a Legend of Maungatahi.*

Communicated by T. PINE.

[Read before the Hawke's Bay Philosophical Institute, 13th August, 1888.]

LONG years ago—how many it is not for me to say, nor does it matter—but not far from here, down the Maungatahi Valley, there lived two chiefs, whose pas were situated on the opposite sides of the Maungatahi Creek. Alas! how the hand of time and the white man's grass-seed alters things! When I first saw the valley I speak of, fern and tutu flourished on the hill-sides, and flax and toitoi in the valley; but this is all altered, and now more than half of its old beauty has fled: the "pakeha grass" grows everywhere, and all the swamps and flats are drained—improved they call it: well, I must say the same, but one cannot fail to regret the old days of seventeen years ago. The white mantle is descending on us all, and the most of us will soon be as bare "where the wool used to grow" as the old hill-pas are now, devoid of their old clothing of tutu and fern.

You will all ask what has this to do with the story; but you must not be too impatient: old memories crowd in upon us, and one can but feel sorry. "We are here to-day, to-morrow away:" lest, however, we go before to-morrow, let us hurry along and finish.

At the time of which I have written there was a great gathering of the different hapus, and it was decided to hold the meeting at Nga Tore Atua and Patangata, which, by the way, are fortified pas on two sugar-loaf hills, rising on opposite sides of the creek, and about three-quarters of a mile apart. Now, a dispute arose between the two pas as to who should supply the food to the people assembled. One chief considered it his sole right on the score of birth, &c.; the other chief advanced arguments so strong that the people took sides, and there was more likelihood of a free Kilkenny fight than of a peaceful gathering. All the "kaumatuas" (old men) were called

together, and after discussing the question in all its phases (and you know how many phases a Maori can get on a question) they decided to ask how much food each chief could supply, and the one who could give most was to have the honour of being made a poor man for the rest of his days.

So they set to work and they dug holes in this flat. These holes were dug in straight lines, each hole about 2ft. across and about 1½ft. deep, and shaped somewhat like a "kopa maori." They then called on the chiefs to see who could fill most holes with food. They set all their people to work: some caught tunas, some pukekos, some kukupas, some kakas; others laid up punishment for themselves in the world to come by slaughtering those pretty little creatures the tuis; others, again, who would make a fortune at home whenever rat-terrier trials are fashionable, went in quest of the kiore. All, or nearly all, returned laden, and more holes were dug and filled; but with no better result than before: each pa was upsides with the other, and when there was nothing left to catch they had to think out some other scheme.

On the side of one of the hills, called Nga Tore Atua, and just below the earthworks of the pa, were two large blocks of limestone, each about 7ft. or 8ft. square: it was decided that these two blocks should be undermined by men appointed by the opposing chiefs, and, whichever stone rolled the furthest across the flat, the people of that stone should be the victors. So they went to work again, and down came one block, which rolled itself a good distance out across the plain, and no one thought that could be beaten; but presently away went the other, and, being, perhaps, better situated than the first stone, it travelled off at a great rate, and rolled and tumbled until it came within a few feet of the creek, at which place it stands to this day. Both stones are there to be seen. Perhaps it is all a myth; but down on the flat all the holes still exist, and one can see where the stones have rolled from.

On the sites of these two old pas fire has done its work until nothing now remains except the deep trench that surrounded one—and a deep one it must have been when the pa was in fighting-trim. Of the other pa one sees the burnt stubs of palisading showing above the surface, but, above all, amongst these are two old heart-of-totara poles, say, 12in. in diameter, and 12ft. to 14ft. high. They stand out in bold relief, sound at heart, but showing much signs of wear. How long they have stood thus no pakeha knoweth—they have been so for many, many years. If they had eyes to see and tongues to relate, what tales they could tell us! what scenes they have witnessed! what cruelties practised! They stood there when this valley was alive with people, and they stand there still.

After all those people have passed away, and unless some person with the heart of a Goth makes use of them as straining-posts in a dividing-fence, or to suit some other emergency, they will long stand erect, like two stern old warriors, exposing their weather-beaten sides to the scorching rays of the sun or the cold blasts of the pitiless storms. Yes, there they stand in their solitude, keeping watch and ward over these old deserted pas; and, as finger-posts, they may yet remain long enough to tell those who come after us of a once-numerous people the last of whom will then long enough have been laid in the dust.

Art. LVI.—*On the Mental Effects of certain Vowel-sounds.*

By R. Copeland Harding.

[*Read before the Hawke's Bay Philosophical Institute, 13th August, 1888.*]

> There is in souls a sympathy with sounds,
> And as the mind is pitched the ear is pleased
> With melting airs or martial, brisk or grave.
> Some chord in unison with what we hear
> Is touched within us, and the heart replies.
>
> Cowper: *The Winter Walk.*

I would ask you to accompany me to-night into one of the less-trodden byways of language. For aught I know the subject may have been dealt with by those of wider knowledge and research; but, if so, I have not met with any record of their observations and conclusions. It touches upon one of the more subtle external qualities of poetry and oratory—the mental effects of certain vowel-sounds.

It is not a new observation that there is a close correspondence between poetry and music, and in order to establish my position I shall treat that correspondence as an actual reality, and not as a mere imaginary parallel. As Pope has said,—

> Music resembles poetry—in each
> Are nameless graces which no methods teach,
> And which a master-hand alone can reach.
>
> *Essay on Criticism.*

And a great living poet has drawn a beautiful parallel between the relation of poetry and music and the relation of the sexes:—

> Till at the last she set herself to man,
> Like perfect music unto noble words.
>
> Tennyson: *The Princess.*

The same image is to be found in Dryden and other English poets.

In the expression of thought, either in prose or poetry, and particularly in the latter, much depends on the dress. The measure and cadence should be in harmony with the subject. The narrative style of the ballad is altogether unlike the narrative passages of the epic, not only in measure, but in language. Certain artifices of style, alliterative and otherwise, are well known. In a passage so familiar as to be almost hackneyed Pope has shown how, even without changing the measure, the sentiment may be emphasized by the sound of the words:—

> 'Tis not enough no harshness gives offence,
> *The sound must seem an echo to the sense:*
> Soft is the strain when zephyr gently blows,
> And the smooth stream in smoother numbers flows;
> But when loud surges lash the sounding shore
> The hoarse rough verse should like the torrent roar;
> When Ajax strives some rock's vast weight to throw,
> The line, too, labours, and the words move slow;
> Not so when swift Camilla scours the plain,
> Flies o'er the unbending corn, and skims along the main.
>
> *Essay on Criticism.*

The effect of this passage is chiefly produced by the choice of consonants; the "labouring lines" being burdened with those uncouth clusters of consonantal sounds which are so difficult to the foreigner, and oftentimes by no means easy to the native. But in the works of the modern masters of English verse there are much more subtle devices than this—so refined as almost to defy analysis. In the skilful use of merely imitative words and measures Tennyson is pre-eminent. The ripple and dash of his poem, "The Brook," and the celebrated imitation of the "horse's hoofs as they canter and canter away," in the "Northern Farmer," are cases in point.

Much has been written on the subject of imitative words, and there is no doubt that (as in the passage just quoted from Pope) they impart a degree of force and vivid expression to both verse and prose. But imitative words are the crudest and most imperfect form of language. It is the child who has not attained the full power of speech who talks of the "moo" and the "bow-wow;" and poetry or oratory which mainly relies on imitative expression for effect is as false in art as "descriptive music" of the "Battle of Prague" order, which gives realistic imitations of cannonading and the "groans of the wounded."

All will admit that in true music—in such a composition, for example, as Beethoven's "Moonlight Sonata"—there are subtleties appealing to the emotions immeasurably beyond anything of the superficial "descriptive" order. The whole composition was suggested by the moonlight streaming through

a window: it would not suggest the same concrete idea to a hearer, but it could not fail, when interpreted by a skilled hand, to awaken a train of feelings parallel to those which inspired the composer—of calm, of meditative repose, and, again, of high aspiration and triumphant hope and trust. To dissect the composition chord by chord and note by note in order to discover its secret charm would be a vain task. The intuitive perceptions of the master could not fail—the sentiment is there, though it defy analysis.

Still, the notes of the musical scale have been thus analysed, and their mental effect in relation to the key-note approximately determined.* According as one or the other tone or group of sympathetic tones predominate, the character of the composition is lively or sad, melancholy or triumphant. The process of analysis is by no means easy, as the individual characters of the tones may be indefinitely qualified by their order of succession, their modulations and harmonies, the relative stress which is placed upon them, and even by the general time of the composition.

It is my object in the present paper to show that similar mental effects are produced by the vowel-sounds of the language, and that their qualities are modified in a parallel manner by succession and emphasis, and to some extent by the consonants with which they are associated. This being admitted, it follows that we have in language an inherent element of expression, both mental and musical, far more subtle than any mere trick of imitative or alliterative words, and, though in itself but an external quality of poetry or oratory, yet possessing an importance fully equal to that of measure or cadence.

I have met with the statement, which my own observation confirms, that there is what may be called a "gamut" of vowels, differing slightly in pitch with each individual, and differing markedly in the case of varying languages and dialects. It is the vowel-sounds (or, more correctly, the vowel-pitch) of a foreign tongue that the learner has the greatest difficulty in acquiring. The ordinary Englishman attempting to imitate the speech of a Scotsman, an Irishman, or a German, contents himself with exaggerating a few of the characteristic peculiarities, and the imitation is a failure; while the genuine dialect will be betrayed by a single monosyllable. This can only be accounted for by the difference of "pitch," which extends throughout the vocal scale.

Swedenborg—whose marvellous insight in almost every

* Curwen thus defines the mental effect of the notes of the scale: "*Doh*, the strong or firm tone; *ray*, rousing and hopeful; *me*, steady and calm; *fah*, desolate or awe-inspiring; *soh*, grand or bright tone; *lah*, sad or weeping tone; *te*, piercing or sensitive tone."

branch of natural science is gradually becoming better appreciated—says that consonants are the essentials of speech; and that vowel-sounds—which are the only sounds the inferior animals utter—have a reference or correspondence to the affections. Much may be said in support of both these propositions.

In the earlier historic ages the Semitic tongues were written and read (as our own language is to-day, habitually, by shorthand writers) without vowels. But it is a singular fact that the subtler shades of meaning in the old Hebrew and kindred dialects were indicated by the unwritten vowels, and that the reader, according to his understanding of the text, would vary even to occasionally reversing the meaning.

It is to the vowel-sounds that language owes its beauty and expression; and in considering their mental effect we have first to divide them into two classes, the long and the short—every long and full vowel having its corresponding clipped and shortened form. It is only upon the vowels that we can dwell, either in speech or song, and, what is more important still, only upon the long vowels. The short sounds are always curt, brief, and abridged. And the first observation I would make is, that—

In dignified, stately, and solemn composition, the long vowels predominate, especially in the accented syllables.

In trivial, light, and burlesque composition, the short vowel-sounds predominate, even in the accented syllables—sometimes to the almost entire exclusion of the long vowels.

As a specimen of dignified composition, take the opening lines of our great English epic:—

> Of man's first disobedience, and the fruit
> Of that forbidden tree whose mortal taste
> Brought death into the world, and all our woe——

Here all the line-endings, and nearly all the accented syllables, fall on long vowels. Let us now take a rhymed poem by one of the masters of English verse:—

> The curfew tolls the knell of parting day;
>   The lowing herd winds slowly o'er the lea;
> The ploughman homeward plods his weary way,
>   And leaves the world to darkness and to me.

And, again,—

> Hark how the sacred calm that breathes around
>   Bids every fierce tumultuous passion cease,
> In still small accents whispering from the ground
>   A grateful earnest of eternal peace.

And so on throughout the composition. But observe the selection of vowels in "A Long Story," a nonsensical poem by the same author:—

The words too eager to unriddle,
  The poet felt a strange disorder—
Transparent birdlime formed the middle,
  And chains invisible the border.
* * * * *
The godhead would have backed his quarrel,
  But, with a blush on recollection,
Owned that his quiver and his laurel
  'Gainst four such eyes was no protection.

Each of these stanzas contains thirty-six syllables. In the first all the vowels are short except five; in the second, all except one! And the loose swing of the measure is quite in keeping.

Let us quote Cowper:—

Would I had fall'n upon those happier days
That poets celebrate, those golden times,
And those Arcadian scenes, that Maro sings,
And Sidney, warbler of poetic prose.
Winter Evening.

Here, again, the long vowels have the great predominance; but turn to any stanza of "John Gilpin," by the same writer, and the short vowels will be found to characterize the whole composition.

It is scarcely necessary further to multiply examples; but I cannot refrain from noting two of the finest of modern hymns—Lyte's

Abide with me,—fast falls the eventide,

and Newman's

Lead, kindly Light, amid the encircling gloom.

Tennyson's poem of "The Brook," already referred to, is a marvel of imitative language. The dash and ripple of the measure is unparalleled in English verse. Sustained notes would be out of keeping with the character of the piece, and accordingly we find a most surprising preponderance of short vowels. At the same time they are managed with such consummate skill that the effect of pettiness and triviality, so noticeable in the examples already quoted, is nowhere to be found throughout the poem.

By thirty hills I hurry down,
  Or slip between the ridges,
By twenty thorps, a little town,
  And half a hundred bridges.

Till last by Philip's farm I flow
  To join the brimming river—
For men may come and men may go,
  But I go on for ever.

In these two stanzas there is scarcely a long vowel. Contrast with this the same writer's

Home they brought her warrior dead,

and his

Break, break, break,
On thy cold grey stones, O Sea!

Note the long vowel thrice repeated in the first line, like the opening chords of the "Dead March." The second line is even more remarkable. With just one short vowel, like a grace-note, cutting it off from the first line, it contains the extraordinary number of six consecutive long vowels.

Thus I have shown that in the mere selection of long and short vowels (apart from the other qualities of composition) there is produced a definite mental effect. And we have no more reason to deride the old lady who "found much comfort in that beautiful word 'Mesopotamia'"—which is mysterious, sonorous, and full of long vowels—than to ridicule the musical enthusiast who is "elevated" or "consoled" by the subtle and far-reaching power of a musical composition. We derive much of our delight in fine poetry from a precisely similar cause.

It would be interesting to follow this inquiry as regards the predominating vowel-sound in English. Those who use a phonetic system of spelling could supply this information. The preponderating use of the symbol *e* in our ordinary writing has no real significance; for not only has it five different powers, but it is extensively used as a modifying character in diphthongs, besides, in its capacity of silent final, merely indicating the lengthening of a vowel.

Before proceeding to the second part of my task—an endeavour to define the characteristic effect of certain vowels—I would advance two more propositions, following as a natural corollary to those already laid down.

There is a distinct affinity between the long vowels and words relating to the higher emotions and intellectual qualities.

The short vowels, on the other hand, characterize words referring to the lower propensities; to such as embody trivial and frivolous ideas; and to the language of cant and slang, abuse and vituperation. And, further,—

That each vowel, long or short, has its own specific mental effect.

Beginning at one extreme of the vocal scale, I take first the long *a* in *far*. This sound is the first in all alphabets, and is the highest and finest in mental effect. It is pre-eminently the vowel of dignity—of meditative, serious, and melancholy composition. This quality has been freely (though doubtless intuitively) made use of in poetic composition. The sound is duplicated with fine effect in a well-known line by Wordsworth,—

Thy soul was like a *star*, and dwelt *apart*.

And in the Authorised Version of the Scriptures—the grandest piece of musical prose composition in the English language—

we have a finer illustration still, where the vowel is thrice repeated, in the manner of a *crescendo* :—

Underneath *are* the ever*lasting arms*.—Deut. xxxiii. 87.

This vowel, which contributes more than any other to dignity in composition, is in marked contrast to the short *a* in *fat*, to which I shall hereafter more particularly refer. Hence the practice—which is, or was, fashionable in America, and of which we have all met with examples—of entirely eliminating this sound, and substituting the short *a*, is a serious degradation of the language. Were there no distinctions in mental effect a change like this would be immaterial; but we know that it is of real significance. When we hear any one speak of the *lăst*, of an *ănser* for answer, or of *păstors* and *măsters*, we are conscious of affectation and effeminacy on the part of the speaker. Compare the doubled long *a* in *taskmaster* with the doubled short vowel in *rapscallion*, and note the contrast. This long vowel *a* is the predominant and characteristic sound in the Maori language, and is generally the vowel selected for the long-drawn note in their songs and chants.

The full *o* is marked by a bold and resolute quality; involving also the ideas of vastness, mystery, and solemnity. We have it in such words as the *open ocean*, and it meets us in the *roll* of its *foaming* waves. It is the key-note of words like *bold*, *noble*, *rover*, *roam*, *foeman ;* and its minor undertone comes in in words like *dole*, *moan*, and *woe*. *Gold*, which, related to *gules*, was commonly pronounced "goold" a century ago, has fallen into this category—partly, no doubt, on account of its spelling, but, I am inclined to think, partly also from a perception of the vowel-quality of the *o*. In dignity and gravity this sound is second only to the *a* in *far*, and is bolder, fuller, and more open in quality.

Fuller still is the broad *a* in *fall*. This is one of the vowels that has a definite meaning in the form of a monosyllable, and that word—*awe*—fairly indicates its quality. It is the vowel of sublimity, a sound entering largely into hymns and the loftier kinds of poetical composition, and appeals to the faculty of "veneration." As a familiar instance of the free use of this sound, and its characteristic effect, may be cited the popular hymn of praise, "Crown Him Lord of all."

The long *e* is the vowel of brightness and clearness, "sweetness and light"—giving its distinctive character to words like *free* and *glee*. It is the vowel of the *sea* (by no means synonymous with "ocean") and its *deeps*, of the *creek*, the *stream*, the mountain *peak* and valley *steep*, the *mead*, the *tree*, and the passing *breeze*. It glitters in the *sheen* of *steel*, and chills us in the *freezing sleet*. In the early spring and through the summer it is the note of Nature, meeting us everywhere

in the song of birds and in the piercing and reedy notes of the cricket and cicada.

The long *a* in *fate* I cannot at present more precisely define than to note that it is characteristic of many words associated with the qualities of firmness and stability.

I pass on now to the short vowels.

Triviality is indicated by the short *i*. We have abundance of instances: *pretty*, *fribble*, *dibble*, *quibble*, *nibble*, *fiddle*, *higgle*, *giggle*, *snigger*, *flicker*, *flipper*, *flippant*, *tipple*, *slipshod*, *milksop*, *silly*, *swill*, *sip*, *snip*, *nit*, *nip*, *jig*, *prig*, *tiff*, *whiff*, and nearly the whole class of affixed diminutives. *Impudent* is vulgarly transformed to "*impident*," thus unconsciously doubling the characteristic vowel.

The short *a* wholly lacks the dignity of the long and full sound of the vowel. A whole string of vituperative epithets owe a portion of their sting to the offensive quality of this vowel: *slattern*, *drab*, *hag*, *harridan*, for example, and the extremely objectionable *blackguard*, in its present wide range of substantive, adjective, and verb. In qualities we have an unpleasant list: *clammy*, *flabby*, *scabby*, *haggard*, *scrannel*; in verbs, to *nag* and to *haggle*.

Lastly, I come to the short *u*, which can boast of a whole vocabulary of contempt and opprobrium—contempt, however, being the ruling characteristic. First we have a small menagerie of unpleasant animals of low degree, whose names are applied freely to humanity: *grub*, *slug*, *bug*, and *skunk*, for example. The same vowel characterizes *mud*, *muck*, *puddle*, *slush*, and *sludge*, a painful swelling called *mumps*, and an unpleasant internal disorder vulgarly called *mulligrubs* (again note the doubling of the characteristic vowel). In the same category may be found a whole collection of terms indicative of various degrees of stupidity—to *blunder*, to *muddle*, to *mull*; a *muff*, *duffer*, and the expressive Scottish term (to which I know of no English equivalent)—a *sumph*. To *funk* is a slang term expressive of cowardice. Objectionable qualities of character are indicated by a long list of similar words, and the vocabulary of slang would be poor indeed without this characteristic vowel. A disagreeable woman is an old *frump*; a man is an old *buffer*, *hunks*, or *curmudgeon*. He is frequently in the *dumps*, is *gruff*, *grudging*, *grumbling*, *grumpy*, *sulky*, *sullen*, and readily *huffed*: he may also be *smug* and *bumptious*. We should feel uncomfortable if in a lonely spot we found ourselves followed by a *hulking* fellow, armed with *cudgel* or *bludgeon*. The contemptuous quality of the vowel seems to be emphasized by the consonant *g* and the compound *dg*; for, in addition to words already quoted, we have *budge*, *fudge*, *drudge*, *dudgeon*, *gudgeon*. Applied to a female we have *slut* and *hussy* (the latter corrupted from the honourable word

"housewife"). A cur of doubtful pedigree is a *mongrel*. I need make no apology here for introducing a number of slang expressions, as these forcibly illustrate the point. In several striking instances the original vowel has been exchanged for the low vowel of contempt: as *cuss* for "curse," *bust* for "burst," and *buss* for the French "*baiser*." In vituperative slang a countenance becomes an *ugly mug*, an ear a *lug*, a prison a *jug*, and a pugilist a *pug*. And this little group suggests to me one of the most vividly-descriptive stanzas in that magnificent old poem "The Faery Queen," where a monosyllable of this class is brought in with striking effect. The Red Cross Knight meets with the foul monster Error in her den, surrounded by her misshapen brood—

> And as she lay upon the dirty ground
> Her huge long tail her den all overspread,
> Yet was in knots and many boughts upwound,
> Pointed with mortal sting: of her there bred
> A thousand young ones, which she daily fed
> Sucking upon her poisonous *dugs;* each one
> Of divers shapes, yet all ill-favoured——

The word is in the most absolute harmony with the repulsive imagery of the passage.

Every newspaper-reader, unfortunately, is of necessity familiar with current slang; and a recent example in an editorial article supplies an excellent illustration of my present point. The writer, it must be admitted, had a difficult task. He had to reply to an article concerning an act of scandalous extravagance, and could not venture either to dispute the facts or controvert the principles. So he simply said that the rival editor was a *mugwump*. This was unanswerable. "Mugwump," it is true, is not in the dictionaries, and has no defined meaning; but the duplication of the vowel (which we find also in the weaker word *humbug*, also of unknown etymology) conveys an unmistakable mental impression. The word is American, and, if not new-minted by some inventive genius, is probably (like "wigwam") a corrupted native term. It is a valuable example of the *vowel of contempt*.*

We need not seek for proofs of the general truth of the propositions I have advanced. The idea having been suggested, confirmations will crowd upon you. Leaving out of consideration those Scripture passages which, as a Roman Catholic writer has said, "ring in the memory like the

* There are two striking exceptions to the contemptuous use of this vowel—*judge* and *just*, and their compounds. For such noble words as *judgment* and *justice* to stand among the outcasts of the language is a kind of contempt of Court. *Trust* is another fine word in similar bad company. I can recall no other exceptions of any importance.

music of church-bells," we have only to examine some of those

> . . . jewels five words long
> That on the stretched forefinger of all time
> Sparkle for ever.

Wherein lies the charm of their vitality? Not in the sentiment—expressed a thousand times before in as many forms. Surely not in any mere jingle of rhyming or alliterative words. It will be found to be deeper—in the subtle melody of the vowels, each appealing to its own specific emotion of the mind. Take the simple phrase, "Hearths and homes." Here we find a sentiment appealing to the highest and purest emotions of the mind, emphasized and enforced by the two noblest and loftiest notes of the vowel-scale. The melody of the tones being in perfect harmony with the sentiment, the two are wedded, and, thus divinely joined by a natural law, they cannot be put asunder.*

Here, I think, we may find the key to the origin of alliteration both in poetry and prose. When we group together epithets like *grasping* and *greedy*, *griping* and *grudging*, *clammy* and *flabby*, we are not following a mere artificial trick of composition, but acting upon an instinctive perception of one of the subtler laws of language itself. And, acknowledging that there is in each of the vowel-sounds a quality answering to a certain mental state, we raise the interjection, despised by grammarians, to the dignity of a "part of speech" in no wise inferior to the onomatopoetic substantive or adjective. It is not by accident, nor is it by mere rhetorical trick, that the preacher exclaims, "*Ah*, how sad the condition!" or, "*Oh*, how grand the thought!" No correct speaker would interchange these interjections.

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* On the occasion of this paper being read, a member of the Institute, commenting thereon, instanced Longfellow's "Evangeline" as a poem abounding in illustrations, and quoted as an example the following beautiful passage:—

> Then from a neighbouring thicket the mocking-bird, wildest of singers,
> Swinging aloft on a willow-spray that hung o'er the water,
> Shook from his little throat such floods of delirious music
> That the whole air and the woods and the waves seemed silent to listen.
> Plaintive at first were the notes and sad; then soaring to madness
> Seemed they to follow or guide the revel of frenzied Bacchantes.
> Single notes were then heard, in sorrowful, low lamentation;
> Till, having gathered them all, he flung them abroad in derision,
> As when, after a storm, a gust of wind through the tree-tops
> Shakes down the rattling rain in a crystal shower on the branches.

The whole poem affords a striking and beautiful example of the artistic use of vowel-music. In one line especially, since reading this paper, I have found a remarkable confirmation of the characters here ascribed to the long vowels:—

> *Over* the *laws* of the land and the *hearts* and *homes* of the *people.*

Each of the long vowels analysed in this article occurs in this line, and each one in the precise mental character which is its peculiar and especial characteristic.

This occult vowel-quality, it may be, accounts also for certain grammatical irregularities otherwise to all appearance quite arbitrary. As, for example, the varying past participle in the case of verbs precisely similar in form. Thus wink, *winked;* think, *thought;* sink, *sunk;* drink, *drunk*. And it is to this characteristic quality of vowel-sounds in suggesting mental impressions that "nonsense verses" may be made to appear so like sense, and also that much egregious and unconscious nonsense in rhyme passes muster as poetry. (Look through some of our most popular hymn-books—and weep!)

The fancy names of fiction strongly bear out my argument. In the names of objectionable and paltry characters the short vowels are freely used, often duplicated, and grouped with uncouth combinations of consonants. Samuel Warren gives us *Tittlebat Titmouse*, *Huckaback*, *Tagrag*, Messrs. *Quirk*, *Gammon*, and *Snap*, &c. Dickens's novels abound with names of this class: *Quilp*, *Podsnap*, *Winkle*, *Stiggins*, *Chadband*, and scores of others might be cited. Meaningless though the name frequently is, the ludicrous or contemptible reference cannot fail to strike the reader.

In the Maori—a soft and euphonious tongue—as I have already remarked, the long *a* predominates. As commonly spoken by the pakeha, it possesses no beauty, but is hopelessly vulgarised. Why? Chiefly because the short *u*, the lowest sound in the vowel-scale (which I have never detected in Maori), is freely introduced. *Mănga* and *māūnga* are both alike *mŭnga* in the mouth of the pakeha. Even the full sound of *o* is degraded to the same coarse and contemptuous vowel. In Captain Cruise's voyages (1828) the name of the chief Hongi is uniformly written "Shungie."

I have one more remark to add—that by a natural process of gradual development we may expect the influence of these qualities upon our language to become still more marked in the future. The continual selection by the best poets and writers of certain appropriate vocal sounds to express particular mental conditions, will add a traditional to an inherent quality. It is so in music, where the power of association is strongly marked. It is impossible, for instance, that Handel's "Dead March" could have affected its first hearers with the tremendous and overwhelming power that it exercises upon our emotions to-day. They might fully appreciate its grand and solemn chords, but it could not move them as it moves us, to whom it comes each time laden with a new addition to its past burden of sad associations. And here, as in other respects, the parallel between language and music will be found upon examination to hold good.

ART. LVII.—*Rabbit-disease in the Wairarapa.*

By COLEMAN PHILLIPS.

[*Read before the Wellington Philosophical Society, 27th June, 1888.*]

I WISH to place on record the facts connected with the outbreak of rabbit-disease in the South Wairarapa, and the methods by which the rabbit-pest was conquered in that district, as a guide for other places, especially insular lands of the globe.

Early in the year 1884, finding that our poisoning operations to reduce the pest were proving futile, and not caring to erect rabbit-proof fencing around my land to protect myself from my neighbours, I determined upon calling the settlers together for the purpose of simultaneously taking proper measures to grapple with the evil. The pest had been worst with me during the years 1881–83, but by 1884 I had personally managed to get it down so far as my own run was concerned. The settlers met upon the 19th April, 1884. A voluntary system of simultaneous action was resolved upon, and I am pleased to be able to say now, in the year 1888, that the pest has been thoroughly conquered over the whole district. The rabbits now only require watching, as they are watched in any country of Europe.

The measures the neighbours adopted were simultaneous poisoning with phosphorized grain and the simultaneous turning-out of the natural enemy, chiefly the ferret. A few of us had been previously poisoning, and breeding and turning out ferrets, and some of us the domestic cat; but the Hon. Mr. Waterhouse was the first to turn out a few ferrets, some four or five years previously. In 1886 Mr. E. J. Riddiford preferred turning out stoats and weasels upon the land, and I think he turned out two to three hundred (one hundred stoats and two hundred weasels). From 1878 to 1888—say in the ten years of the pest—the measures taken, therefore, to grapple with the evil were hunting and shooting with dog and gun, poisoning with phosphorized grain, and the turning-out of cats, ferrets, stoats, and weasels. Seeing that we were turning out the natural enemy, I induced the settlers not to make use of traps. At the present moment so little is this question understood that a reference to Mr. Bayley's (the Chief Rabbit Inspector of the colony) annual report for 1888 will show that the Government and every Rabbit Inspector are willingly allowing the use of traps in every other district of the colony. Of course this is almost fatal to the natural enemy. The use of traps must be absolutely prohibited. With regard to rabbit-proof fencing, I always thought it a

weak thing, and I would have nothing to do with it. I preferred to reduce the pest upon my neighbours' runs as the best method of protection for my own land.

Time ran on; the rabbits were disappearing fast, the lands were becoming clear; and now a rather great factor of suppression appeared—I suppose I may say the greatest of all—viz., disease—bladder-worm or tape-worm of the dog, concerning which the facts are as follows: Early in the year 1886 I had noticed that my rabbiter's pack of dogs were looking miserably-poor, half-starved, mangy skeletons. I spoke to the man, and told him that I could not allow him to keep his dogs in that condition. (I had now only one pack of dogs employed: formerly, in 1882, I had four. I think I sent home about one-quarter of a million skins during the pest.) I had previously noticed that a neighbour's pack of dogs were in much better condition, and that neighbour's rabbiter had told me that he gave his dogs areca-nut to relieve them of worms. I advised my rabbiter to give his dogs the same medicine. And, although Professor Thomas, in his late report, tells me that I did wrong in giving the dogs this medicine, yet must I, from practical experience, say that to it, and the consequent dissemination of pieces of the tape-worm all over the run during the last two years, can I alone attribute the thorough infection of my land with bladder-worm or rabbit-fluke. The diseases of liver-rot, scab, and lice also appeared. The few rabbits that I have remaining are now nearly all diseased. I may perhaps have been wrong in administering monthly doses of the medicine—two-monthly doses would have been better; but that the mistake was not fatal is proved from the fact that the run now is thoroughly infected with the disease. I therefore still advise runholders in the South Island to each use a pack of dogs, feed them upon raw rabbit during the week and boiled rabbit upon Sundays, and give them two- or three-monthly doses of areca-nut. For I must respectfully ask scientific men, like Sir James Hector and Professor Thomas, to concede a little to practical experience in this special matter, seeing how great the evil really is to be contended with. (A reference to Professor Thomas's report will show that that gentleman lays great stress upon the efficacy of the winter poisoning in my district. All I can say is that the winter poisoning did us very little good. Under it the rabbit-pest was as bad as ever.)

About eight or nine months since my rabbiter informed me that he had applied to the New South Wales Government for the reward offered for a proper method of suppressing the pest in Australia. His suggestion was, infection with venereal. I did not believe in this, and considered in my own mind that the disease I had upon the run would be a

better thing for Australia. We often discussed the matter amongst ourselves. The rabbits had disappeared like magic. Surely the remedies we had taken would apply to Australia. As to the ferret, I was not at all satisfied with its action. It did not appear to have done nearly the good that I had anticipated. The cats were doing as much good, I thought. I placed as little reliance upon the ferret as I did upon poisoning or rabbit-fencing. The ferrets died off rapidly from distemper. They did not appear to at all increase in sufficient numbers to cope with the evil. Although a gill-ferret littered in large numbers, yet the young ones did not appear to survive. But they had done a certain amount of good. (Consequently I still advise their use. I would say this, however: that they must not be relied upon in the South Island for the high, snowy lands.)

I therefore determined to apply for the reward myself, and I sent one of the diseased rabbits to Sir James Hector to ask his opinion. That gentleman replied favourably. He had previously received two specimens of the disease from the Wairarapa, and he had himself seen a virulent disease of some kind amongst the rabbits in North America. Sir James had previously spoken to me about this disease that he had observed, and he therefore made up his mind definitely to identify it, upon receiving this third specimen from me, with the North American disease. Professor Thomas differs from this view, and says that the tape-worm is not the same—that it is totally distinct. It may be so, and Sir James Hector may be wrong. Our rabbit is not the same animal as the jack-rabbit of North America—a sort of hare; but, nevertheless, I wish to record my thorough appreciation of Sir James Hector's services in identifying the disease so far as he did. Sir James did not know which animal acted as host in passing the particular worm that is here. I said it was the dog. We had all along observed it coming from the dog. Neither Sir James nor Professor Thomas thought it could be the tame dog, although Professor Thomas was careful to express no decided opinion. It will be observed upon reference that Sir James Hector thought it came "probably from the wild dog and cat." Of course we have wild dogs, and I had turned out many cats, which have thriven remarkably well; and these may have started the disease: but the tame dogs certainly do carry it on, and they will spread it readily in the South Island. The cats may also spread it, as there are at least a hundred cats upon my run now. The disease only requires to be started upon the runs in the south or elsewhere to perform as good work as it performed with us in the Wairarapa.

My letter to the Colonial Secretary of New South Wales, applying for the reward, found its way into the newspapers of

Australia, and immediately I was told by many of my fellow-settlers in the Wairarapa that the disease was no new thing; that some of them had observed it two, four, even six years ago; that they had it upon their runs, and other diseases as well, such as liver-rot, mange, scab, and lice. The generality of them said the disease (bladder-worm) was no good, and wondered at my taking any notice of the matter. Many of them, and the general number of the rabbit-men and Maoris, considered that the bladders were caused by gunshot wounds. Even the other day, when I was bringing a good specimen of the disease down to Sir James Hector, the Maoris clustering round the box remarked, "Ah! that rabbit was wounded." All this evidence points to the one fact that for six years past this disease has been silently at work upon the runs in the Wairarapa, and to it may be attributed, just as much as to the winter poisoning or the ferrets, the further great fact that in the Wairarapa the rabbit-pest has been conquered. (I attribute the subjection of the pest to the three things acting in combination.) The mange, itch, or scab had also been observed upon my own and the neighbouring runs; but the rabbiters considered that such rabbits had been scorched or badly burnt in the many fires lit to clear off the scrub. Liver-rot had also been observed, especially upon Mr. Tully's run—a run celebrated for the bad state of the rabbit-pest there, but which I am happy to say is now almost clean. Professor Thomas's interim report does not say whether liver-rot is attributable to bladder-worm—or rabbit-fluke, as Sir James Hector named it: I fancy it is.

Now, let us leave detail and go into principles. Let us see what this bladder-worm really means. Let us take an atlas of the earth and inquire into the reasons why the four great continents of Europe, Asia, Africa, and America are free from the rabbit-pest, and why it is so bad in Australia and New Zealand. If my course of reasoning is found to be sound, then, surely, M. Pasteur's proposed mode of suppressing the difficulty with cholera-microbe solution will be found to be as absolutely useless as our winter poisoning, and very far indeed removed from the right method of cure. I use the words "absolutely useless" in this sense: that it will be no good M. Pasteur sweeping off the rabbits by millions if they breed up again, and have to be again swept off. Under the winter poisoning we are sweeping off the rabbits in New Zealand at the present moment at about fifty millions a year.

And, first, it will be remembered by members of this Institute that last year I read a paper upon "A Common Vital Force." The reasoning in that paper has furnished me with matter for clearing up the present question. My argument is as follows—and Professor Thomas, before sending in his full

report, will do well to think over what I am about to say, and to amend his summary of conclusions at the end of his interim report lately presented to Parliament:—

The rabbit appears to have started in Africa. Negro legends all point to it as the cunning animal, just as our legends point to the fox. From Africa it passed to Asia and Europe, as European lands emerged from the sea. (I consider Africa the oldest continent, geologically, and the negroes the oldest race of men, ethnologically.) From Asia it passed into America, or the jack-rabbit there may have been in America coterminous with the rabbit's existence in Africa or Asia. With the rabbit went the stoat, weasel, ferret, cat, dog, fox, wolf, and other natural enemies. I am speaking now of many thousand years ago—long before men ever appeared upon the face of the earth, but still while the four present great continents were continents, and Australia and New Zealand isolated.

And these animals which we call the natural enemies were specially sent by nature to watch the rabbit and prey upon it, and prevent its excessive increase. Thus the common vital force always acts. One order of creation is not allowed to take possession of the earth—another checks it; and so the balance of utility is preserved.

Sir James Hector, thinking as I think, stated some months since that soon there would be no rabbits in New Zealand. I would point out to Sir James that in saying that he has gone too far. Nature checks excessive increase, it is true, but nature does not willingly allow any one order of creation to be exterminated. On many an estate at home there will still be found, after a thousand years of experience, the fox, the stoat, the weasel, the dog, the cat, and the rabbit side by side. Trap off the ground-vermin, as it is called, and the rabbit will rapidly increase; so that any idea of our depending entirely upon bladder-worm or any disease must be abandoned. The rabbit will never be exterminated now from the lands of Australasia. Nor is it advisable for us to exterminate it.

But there is a great distinction between the rabbit as an animal and the rabbit as a pest. Nature carefully makes this distinguishment in all living things. Only those things came to this planet of use to it, as its climatic conditions proved favourable to their reception, and each thing carried with it its own check from excessive increase. The general check (this course of reasoning supposes space to be filled with germs, and other planets inhabited) is a worm of some kind. For when any living thing becomes too thick—be it man, sheep, rabbit, pig, horse, ox, or other animal—immediately the land becomes infected by the excessive excreta of itself or its natural check. I rather fancy that its own excreta first starts

the check, which rapidly spreads by means of the host. In the sheep we see it when we say that the land becomes sheep-sick. Upon such lands the hoggets get the lung-worm, and die off. So that, supposing we tried our best to keep but one animal running constantly upon one set of lands, the end would be that that animal would dwindle down to very few indeed. In the case of the rabbit its own intestinal worms or the intestinal worms of the natural enemy are always ready to infect the lands and guard those lands against entire occupation. And so determined is nature to do this that away up in the arctic regions, where the rabbit, jack-rabbit, and hare can go in comfort, being furred animals, there is it followed by the stoat changed into an ermine. The stoat puts on a warmer coat, and follows the rabbit even to the poles. For that reason stoats are alone to be relied upon by our Government here for suppressing the plague in the high snowy lands of the South Island.

Now let us look at the atlas, and see the position of Australia and New Zealand. What is it? Disconnection from the four great continents. Here there were neither rabbits nor any natural enemy (I allude to the end of the secondary period in geology, when Australia is supposed to have been separated from the mainland). The land was clean from either. Lately we have brought the rabbit, and, finding no check either against itself or against it as a pest, it rapidly developed into the pest form. Neither ferret, stoat, weasel, fox, nor wolf was here to infect the lands with the tape-worm eggs, and so the rabbit throve and multiplied. The dog alone was here, and in the Wairarapa the dog appears to have carried out nature's law of check. My accidentally giving the dogs areca-nut but assisted nature's law.

Of course, I do not say that the tape-worm I use is the worst form of tape-worm. There are two hundred and fifty different kinds of tape-worm, and I have no doubt that the tape-worm of the fox and wolf is a far more virulent disease than the tape-worm of the dog. But then I do not like to introduce such animals into Australasia, amongst our sheep. The Hon. Randall Johnson tells me that a proposition comes from Africa for us to use here the civet-cat and the meer-kat. (The civet-cat is closely allied to the aard-wolf.) But, again, I say that I do not like introducing here more ground-vermin than are absolutely necessary. I find that I have succeeded with the dog, cat, ferret, stoat, and weasel. What necessity is there to introduce anything further yet awhile? I feel almost sure that these animals will perform the work for Australasia. At any rate they should be tried before introducing any of the other animals. We never know how the *feræ naturæ* develope in these new lands. These require their

check just as much as the rabbit requires its check: hence my aversion to their introduction. Had the dog, cat, and ferret been capable of performing the work of suppression, I would never have introduced the stoat and the weasel into the Wairarapa. At any rate, if we have to concede to the full extent of the round of nature's law, let us wait until population becomes a little more dense with us, to impose the proper check of man.

From all this it will be seen how totally wide M. Pasteur is from the truth, and how little dependence can be placed upon purely scientific reasoning in dealing with this question.

That the rabbit multiplies itself rapidly upon insular lands of the globe is seen from two instances recorded in history. In A.D. 1 the inhabitants of the Balearic Isles petitioned the Roman Emperor Augustus for assistance in subduing a rabbit-pest there. Two legions of the Roman army were sent to get the plague down. It is evident now, from my course of reasoning, that these islands wanted the natural enemy.

Also, in the case of one of the Canary Islands, or Teneriffe. Prince Henry of Portugal, I think, sent some rabbits to one of them, and the inhabitants had very great difficulty in subduing the pest. I am a little uncertain as to the facts in this case, but I remember meeting with it some time since, accidentally, in the course of reading. This case, and the former one of the Balearic Isles, and New Zealand and Australia, are exactly alike. A narrow view of this question is therefore quite inadmissible. We can but look at it from the point of view I suggest—viz., with an atlas of the globe before us. Hitherto we have regarded the matter too narrowly in New Zealand, and M. Pasteur's remedy, strange to say, is too narrow also.

With regard to rabbit-fencing: I do not object to rabbit-fencing, but I consider it a waste of money. The best and most sure fence is the egg of the tape-worm upon the grass. The calculation for each dog is as follows: 1 × by 100 tape-worms, × by 100 segments, × by 1,000 ova.

As to the expense of the remedy, the beauty lies in its cheapness. Supposing the owner of each run in the South Island got but two of my diseased rabbits, and fed those rabbits to two hungry dogs in his pack, and then went steadily hunting over his land, the moist lands would quickly become infected with the tape-worm eggs. The rabbits would eat them and get fluked, and soon the whole pack of dogs would be infected. The dogs would then infect the whole of the lands. Whether the ferrets, stoats, and weasels also carry the worm about I cannot say. I firmly believe they do; but I have all along been quite certain that the tame dog does so, and I think the cat also. Neither Sir James Hector nor

Professor Thomas is able to tell me anything about this; so I can but be guided by my practical experience. This is why I object to rabbit-fencing. I wish free, open fences for the dog and natural enemy to disseminate the tape-worm ova.

With regard to the danger of the sheep becoming fluked, I have never heard of a single case of the sort in the Wairarapa during the six years the disease has evidently been silently at work amongst the rabbits. Nor do I think that the bladder-worm of the rabbit can possibly infect the intestines of the sheep. Each order of nature has its own check. This can be seen from the fact that there are some two hundred and fifty different sorts of tape-worm. The rabbit might carry the proper sheep-fluke about in occasional instances, but I do not think that the sheep could possibly carry the rabbit-fluke about. At any rate, my sheep have been running upon my badly-infected rabbit-fluked lands, and no instance of death has yet occurred.

I need scarcely point out the severity of any tape-worm disease. A few years since seven hundred thousand pigs died near Chicago from trichinosis; last year a score of thousand hoggets died from lung-worm in the southern portion of this North Island of New Zealand; millions of sheep die in England from sheep-fluke. These are but instances of the severity of nature's laws. And nature's proper laws are continuous; not like M. Pasteur's remedy, or our own winter poisoning. How well do we know here that the rabbits grew proof against the poisoned grain, and refused to take it! So will the rabbits grow proof against cholera-microbes. Even a few fowls in each hen-roost always escape the ravages of chicken-cholera. Again, there were, and are still, many places in the South Island where we could not lay the poisoned grain. This escape from poison and disease, and these inaccessible places, yearly afford bases for the rabbits to breed up again. But there is no escape from bladder-worm or liver-rot.

With respect to the time the disease takes to effect the death of the rabbit, Professor Thomas mentions thirteen and twenty-one days after infection. We have always thought it took longer, but Professor Thomas thinks that he can make the disease even still more fatal. This is good news; but I do not think there is any necessity for it to be more fatal than it is. My run is clear now from the pest. I keep but one rabbiter and a pack of dogs over twelve thousand acres, and he catches about twenty-five rabbits a week. He could look after twenty thousand acres just as easily as twelve thousand. (I do not think his time thrown away in regularly going round the run. He saves his wages in other directions.) I am, however, indifferent what disease is selected, provided one of

nature's true remedies is applied. As to any disease like cholera suddenly sweeping off millions, I do not believe in its applicability to our present circumstances. Too much virulence would do harm.

In the use of so many dogs there is, of course, a danger of some dogs going wild. I should recommend the Government to publish the resolutions the settlers arrived at in my district, in 1884, upon this question. We are now through the rabbit-pest, and I do not think the wild dogs have killed a thousand sheep during the last four years over a million acres. Still, there are a few dogs gone wild in the bush, which we occasionally hear and see; but these can easily be got if the search for them is properly gone about. Prevention in this matter is better than cure. I prefer this danger to the introduction of the fox or wolf tribe.

There is some talk of this rabbit-disease attacking man in the form of hydatid. So it will. Hydatid from sheep attacks a few persons in Australia. Hydatid from the dog attacks a few of the Iceland people. I do not think much of these things. People cannot give up eating rabbit or mutton, or keeping dogs. To do that is the true remedy for the alarmists, and it is impracticable.

I would repeat that Professor Thomas does not draw the same conclusions from the mode of conquest of the pest in the Wairarapa that I draw. The winter poisoning had little or no effectuality. The ferrets worked well only in isolated places; in other places they would not live at all. But the three things acting in combination—viz., the poisoning, the natural enemy, and these diseases—effectually did the work of suppression. The poisoning swept off the millions; the ferret, cat, stoat, and weasel ate the young ones left; and then this bladder-worm and liver-rot attended upon all and completed the cure: but the poisoning itself was of little good. Herein it will be seen that practical experience is better than scientific conclusions. I hope Mr. Thomas, after reading this paper, will amend his interim report in the proper direction. It is not because the tape-worm here may not be exactly the same tape-worm that sweeps off the jack-rabbit in North America that Sir James Hector was wrong in the application of the general principle. That principle is that the excess of every order of life is held in check by some particular worm.

On the other hand, I must say that I saw far more from my ten years' practical experience in reducing the pest than Sir James Hector or Professor Thomas could tell me about it. Combining these things with M. Pasteur's proposals, I must be excused for doubting scientific conclusions. Sir James Hector proposes the introduction of the kit-fox here: I

think such a step would be wrong and unnecessary yet awhile. My opinion is that the wolf and fox tribes are the natural enemies of the sheep. We are clear of sheep-fluke now in Australasia, and I have no wish to introduce it. The bladder-worm hydatid of the rabbit, and sheep hydatid, are luckily two distinct things.

With respect to complete rabbit-extermination, I wish to say that it will be most inadvisable to attempt such a measure; and if it is attempted in Australia it will not succeed.

I am told that I am making too much of these diseases, and that specially favourable circumstances aided me in suppressing the pest in my own district. Those who say this do not see the importance of the principle contended for. So great is that principle that I have offered to reduce the rabbit-pest to a minimum in the South Island of this colony if I am allowed four years in which to do it. For that was the time it took me to reduce the pest in the South Wairarapa.

Art. LVIII.—*The Ancient Moa-hunters at Waingongoro.*

By Lieut.-Colonel McDonnell.

Communicated by James Park, F.G.S.

[*Read before the Wellington Philosophical Society, 17th October, 1888.*]

The date of the extinction of the moa has always been a favourite theme for discussion among scientists in New Zealand, some contending that it had long ceased to exist before the advent of the Maoris to these shores, others arguing that it lived contemporaneously with this race down to very recent times.

The former hypothesis has for its champion and principal exponent Mr. Colenso, of Napier, who states that his belief is based on the fact that there is nothing in the proverbs or stories of the Maoris to show that they knew anything of this gigantic wingless bird. It seems, indeed, strange to me that an authority on Maori manners, language, and mythology of such eminence as Colenso should never have gleaned anything about the moa from the natives he met. This is so contrary to my own experience that I cannot refrain from narrating an incident that came under my observation during the native war on the west coast.

It was some time in 1866, during a visit Sir George Grey, at that time Governor, paid to the West Coast, that I, with Kawaua Paipai and other natives from Wanganui, accom-

panied Sir George to the mouth of the Waingongoro River, where were the redoubts held by the Imperial troops. Here Sir George met Wiremu Hukanui, a chief of the Ngatiruanui, and supposed to be neutral; he was also a relative of Paipai.

After the talk was over Wiremu left, when a discussion arose about the moa, and Kawaua Paipai stated that in his youth he had joined in hunting the moa on the Waimate Plains, which are close by. On being questioned, he gave a description of how they used to hunt and destroy this grand old bird, which was as follows: "The young men," he went on to say, "stationed themselves in various parts of the plains, and when a moa was started it was pursued by one of these parties with wild shouts, and sticks, and stones, until they were tired, when another detachment would take up the running, and so on, until the moa was exhausted, when a chief would administer the *coup de grâce*." Paipai said that great efforts were made to drive it into the high fern, the more easily to tire it out. "I," continued the old warrior, "was a youngster at that time, and often used to join in the chase."

I forget now whether it was Sir George or one of the officers who expressed doubts as to the absolute correctness of what Paipai had stated, thinking he was simply relating what he had heard, which doubt roused the old man's ire. He got up, and, casting his eye around as if seeking aid to his memory, said, "What I have told is true; and we used to bring them here to our fishing-village, and cook them in large ovens made expressly for them. Let some men bring spades, and I will show them where to uncover the ovens." Some six or seven fatigue-men were assembled, and Paipai pointed out where they were to clear away the sand. After shovelling away some 6ft. square of sand, 3ft. in depth, a stone about the size of a 32lb. shot was turned up, blackened and burnt by fire, and then a number of other stones that had evidently been used for cooking, until a Maori oven some 5ft. in diameter was uncovered, containing over and under the blackened stones heaps of broken and partly-charred moa-bones—portions of skulls, and huge thigh-bones, which latter Paipai said had been broken, so that the oil, or fat, could be sucked out of them. The ring-bones of the throat, or gullet, over an inch in diameter, were there in plenty—like curtain rings. I threaded a number on a flaxstick. More ovens were uncovered, and Sir George obtained some good specimens. I think Dr. Spencer, now in Napier, got a number, as did many others.

Paipai described the plumage, which he said was of a brown colour, and unlike that of the kiwi, the feathers being larger and coarser, and more like those of the emu. He said the moa fought fiercely when brought to bay, and that it struck out with its feet, but was easily killed with clubs.

Kawana Paipai died some four or five years ago. He must have been over ninety, at least, and by what he said he was about sixteen years old when these birds were killed and eaten; so that would bring the time to near the beginning of this century.

I am indebted to Mr. Park for the following extract from an interesting article on the excavation of an ancient *umu* at Awamoa, contributed to the *Wellington Spectator* in 1848 by Mr. Mantell.

"Last Christmas I camped at the mouth of the Awamoa, a small stream between Kakanui and Oamaru, having found there a few weeks before the *umus* of the extinct aboriginal tribe of Waitaha, full of bones, stones, &c.; and devoted a day to digging. The old surface, in which the *umus* had been excavated, was buried under a foot of alluvial deposit; beneath this the old sandy soil was blackened by the mixture of charcoal, large lumps of which were scattered among the chaotic mass. The primeval savages had evidently thrown back into the *umu* the remains of each feast, and lighted over it the fire to prepare the next. The disagreeable flavour which the scorched bones must have lent to each succeeding banquet was, we may hope, some slight punishment to them for exterminating the moa. Their animal food seems to have consisted of *Dinornis* (very rare), *Palapteryx*, *Notornis*, *Aptornis*, *Apteryx*, *Nestor* (kaka or kea), cormorants, gulls, ducks, and other small birds; *dogs;* a small rat; *Haliotis*, fresh-water *Unios*, and other shell-fish; seals, porpoises, sharks, eels, and other fish: so that the bill of fare was varied enough. The bones of all were matted and locked together most intricately, large angular burnt stones (originally round boulders, cracked by the fire) and a wet, black, sandy soil filling all interstices. Here and there we met relics of their dinner-equipage in the shape of large and small fragments of flint, totally different from any in the neighbourhood, and said by my respected friend old Governor Railway,* who formerly lived there, to come from Lake Hawea. Sometimes an ancient aborigine or his dog seemed to have retired to discuss a tit-bit in solitude, for imbedded at intervals over the surface of the ancient *kaika* (whose former extent is well marked by the blackened subsoil) we found an odd bone or so: I think the dogs must have done this, as the bones were generally foot- and toe-bones, which would probably have fallen to their share. The only human manufacture we found was a small ball of baked clay, the work, most likely, of some ingenious young savage, stopped on the threshold of the invention of pottery by a vindictive *tibia* thrown at his head by his enraged parent, with a

* Te Wharekorari.

concise order to go egg-hunting and not waste his time that way."

I do not propose to treat this subject from a scientific point of view; but the bones and ovens I saw at Waingongoro in 1866, and the evidence obtained by the Hon. Walter Mantell in 1848, at Awamoa, certainly afford proofs that the moa lived down to very recent times.

ART. LIX.—*On the Mechanical Description of a Straight Line by means of Link-work.*

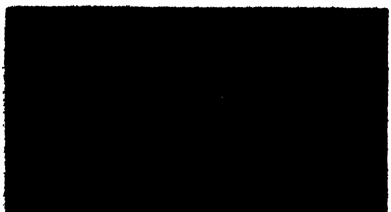
By W. STEADMAN ALDIS.

[*Read before the Auckland Institute, 22nd October, 1888.*]

THOSE who are familiar with the early history of the steam-engine will remember that in the first form, known as Newcomen's, the pressure on the piston was only employed to pull the beam down, and that thus an attachment of the piston to the beam by means of a chain passing over a circular head was sufficient to insure the proper motion. When, however, Watt closed in the cylinder and drove the piston both up and down by steam-pressure, it became necessary to connect the rectilinear motion of the piston-rod with the circular motion of the end of the beam in a manner which should enable the piston-rod to exert a push as well as a pull on the beam.

The geometrical problem was to discover a means of making one point move in a straight line while connected by rigid bars with another point moving in a circle.

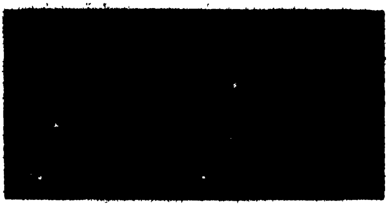
The solution adopted by Watt was an approximate one, and depended on the following geometrical proposition:—



Let AB and CD be two fixed rods capable of turning in the same plane about the points A and C, while their other ends are connected by a bar, which is hinged to them at B and D respectively. Then, if this arrangement of bars be

made to assume all possible positions, any point, P, in the connecting bar will describe a curve called a lemniscoid, of the general shape of an elongated figure of eight. At the point of crossing of the two branches a portion of either is very approximately a straight line, and thus if the rods AB and CD do not turn through too great an angle, P may be attached to a piston- or slidevalve-rod, which is constrained to move in a straight line, without danger of breaking the machinery.

The arrangement thus suggested would require a greater space for the machinery than is ordinarily available if CD represented the half of the beam and P the point of attachment of the piston-rod. By means of an arrangement of parallel rods the motion of P is multiplied, so to speak, in the following manner:—



For simplicity's sake, suppose that AB and CD are equal, and P the middle point of BD. Imagine CD to be produced to E, making DE equal to CD, and let two other rods, as EQ and QB, equal to BD and DE respectively, be hinged to the others at E and B, and to each other at Q.

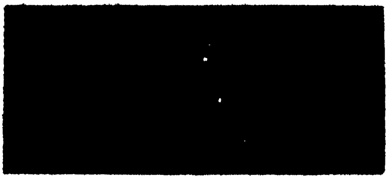
Then elementary geometry shows that throughout the motion DEQB is always a parallelogram, and, since QE is double of DP, and CE double of CD, the points C, P, Q are in a straight line, and CQ is always double of CP. Hence the path described by Q must be similar to that of P on a scale twice as large, and, as P moves approximately in a straight line, so also will Q.

CE represents half the beam, and Q is the point of attachment of the piston-rod, while P serves as a point of attachment of a pump- or valve-rod.

These motions are illustrated by the models shown. The problem of connecting an exact rectilinear motion with a circular one has only been solved in comparatively recent times, the first arrangement of link-work effecting this object having been devised by M. Peaucellier, a French engineer officer, in 1864. Other methods of achieving the same result have since been discovered.

The geometrical theorem on which M. Peaucellier's apparatus depends is the following:—

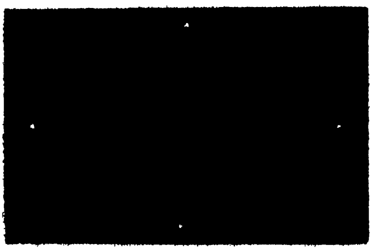
If a fixed point, A, on the circumference of a circle be joined with any other point, P, and a length, AQ, be measured on AP such that the product of the lengths AP and AQ always has the same value, then, as P moves round the circle, Q will move on a straight line.



Let AB (figs. 1 and 2) be the diameter of the circle through A. Take AC so that the product of AB and AC is equal to the constant value of that of AP and AQ. Then C is a fixed and determinable point.

If then CQ and BP be joined, since AP AQ is equal to AB AC, it follows that PBCQ is a cyclic quadrilateral, and therefore the angle ACQ is equal to the angle APB—that is, is a right angle. Hence Q always lies on the straight line drawn through C at right angles to AC.

The Peaucellier cell, as the framework is called, consists of seven bars, four of which are of one length, two more are equal to one another, but unequal to the former, while the seventh may be taken arbitrarily. These are jointed together as in fig. 3, the four equal bars forming a rhombus, ABPD, the other two equal ones being attached to this at B and D,



and to each other at O, while the seventh is attached to the rhombus at A.

The points C and O are fixed points, and the distance

between them is equal to the length of the seventh bar, CA.

Elementary geometry shows that the points A, O, P will always lie in a straight line, and also that BD is at right angles to AP, and bisects it.

Hence (by Euclid, ii., v.) the rectangle AO OP is equal to the difference between the squares on AE and EO, or to the difference between the squares on AB and BO—that is, the rectangle AO OP has always the same value in whatever manner the bars may be turned round their hinges. But as they turn the point A moves on a circle whose centre is C and radius CA, and which therefore passes through O, since CO is equal to CA. Hence P must move on a straight line perpendicular to CO.

If the distance CO be taken different from the length of CA the point P will describe a portion of a circle.

A second method of producing a rectilinear motion by link-work, depending on the same geometrical proposition, requires only six bars, equal in pairs.

Four of these are linked together so as to form an anti-parallelogram, ABDC; AB, CD being equal bars, and also AC, BD. Then it is a consequence of elementary geometry

that, if P, Q, R be three points on the rods AC, AB, CD respectively such that PQR is parallel to AD or CB in any one position of the framework, they will always satisfy this condition in whatever way the bars be turned about their joints.

The remaining pair of bars are linked to AC and AB at P and Q, and to each other at O.

Then the ratio of PQ to BC is fixed throughout the motion, and also that of PR to AD. Hence the ratio of the product of PQ and PR to that of CB and AD is given. But this latter product is invariable (Euclid, vi., D). Hence, also, the former has always the same value.

Thus, if OP be fixed, since Q must describe a portion of a circle, with O as centre, passing through P, the point R will describe part of a straight line perpendicular to OP.

As the bar OP does not move it may be dispensed with, provided the points O and P are fixed at a distance from one another equal to OQ. Thus this mechanism requires only five bars, instead of the seven involved in the Peaucellier cell.

Another arrangement of links, by which a very long swing in a straight line can be obtained, requires some preliminary geometrical explanation.

Let ABCD be any quadrilateral, and APQR a second having its sides AP AR coincident in direction with AD and AB. Let also the lengths of the lines AP, PQ, QR, RA be in the same ratios to one another as the lengths AB, BC, CD, DA. Then it follows that the figures ABCD and APQR will be similar, and if the lines represent rods jointed at all the points of meeting the angles ARQ and ADC will always remain equal in whatever manner the rods are turned about their joints.

We shall now prove that, if S be any point in PQ, a point E can be found in DC such that when ST and EF are drawn perpendicular to AD the length FT will remain invariable in whatever manner the links are turned about their hinges.

Let the lengths of AB, BC, CD, DA be denoted by a, b, c, d, and those of AP, PQ, QR, RA by p, q, r, s. Also, let the angle ABC or APQ be called θ, and the angle ARQ or ADC be called ϕ.

Then, joining AQ, by a well-known trigonometrical theorem—

$$AQ^2 = p^2 + q^2 - 2pq\text{Cos}\theta = r^2 + s^2 - 2rs\text{Cos}\phi.$$

$$\therefore\ pq\text{Cos}\theta - rs\text{Cos}\phi = \tfrac{1}{2}(p^2 + q^2 - r^2 - s^2).$$

Let, now, $PS = x$, $DE = y$,

Then $FD = y\text{Cos}\phi$, $TP = x\text{Cos}(\pi - \theta) = -x\text{Cos}\theta$.

$$\therefore\ FT = PD - DF - TP.$$

$$= d - p - y\text{Cos}\phi + x\text{Cos}\theta.$$

If, now, y be so chosen that $\frac{y}{x} = \frac{rs}{pq}$, we have

$$x\text{Cos}\theta - y\text{Cos}\phi = x\text{Cos}\theta - \frac{rs}{pq}x\text{Cos}\phi.$$
$$= \frac{x}{pq}(pq\text{Cos}\theta - rs\text{Cos}\phi).$$
$$= \frac{x\,(p^2+q^2-r^2-s^2)}{2pq}.$$

Hence, $\text{FT} = d - p + \frac{x}{2pq}(p^2+q^2-r^2-s^2)$, which is independent of the angles θ and ϕ, and retains therefore the same value, however the links be turned about their joints.

By taking S suitably, this value of FT may be made anything we please. If, for instance,—

$$\frac{x}{pq}(p^2+q^2-r^2-s^2) = -(d-p),$$
$$\text{or } x = \frac{pq(d-p)}{r^2+s^2-p^2-q^2},$$

FT becomes $\frac{1}{2}(d-p)$ or $\frac{1}{2}$DP.

Hence, if FO be taken equal to FD, OT will also equal TP. It follows that EO must equal ED, and SO must equal SP.

Thus, if to the original framework there be attached two other links at the points E and S, equal respectively to ED and SP, and these links be hinged together at O, the point O must always lie somewhere in the straight line AD.

Thus, if APD be fixed, and the other links be moved any possible way, the point O will describe the straight line DPA.

In the particular case which the model illustrates the points R and B coincide, so that $a = s$; also q and r are equal, and therefore also b and c. The figures being similar, we have in general—

$$\frac{a}{p} = \frac{b}{q} = \frac{c}{r} = \frac{d}{s},$$

Hence, in this particular case $pd = as = s^2$, and

$$x = \frac{pqd - p^2q}{s^2-p^2} = \frac{(s^2-p^2)q}{s^2-p^2} = q.$$

Hence the point S must coincide with Q.

Also, $y = x\frac{rs}{pq} = x\frac{s}{p} = q\frac{a}{p} = b$; so that E coincides with C.

ART. LX.—*The Knowledge of Cattle amongst the Ancient Polynesians.*

By EDWARD TREGEAR, F.R.G.S.

[*Read before the Wellington Philosophical Society, 17th October, 1888.*]

PLATE XXXVI.

"In the ox is our strength, in the ox is our need; in the ox is our speech, in the ox is our victory; in the ox is our food, in the ox is our clothing; in the ox is tillage, that makes food grow for us."—Bahram Yast, xx. (Zend Avesta).

WHEN, in writing the "Aryan Maori," I expressed the opinion that the Polynesians (Maori) showed in the construction of their language that they had once been acquainted with horned cattle, I laboured under the disadvantage of having to economize greatly both in time and space. Three years have passed away, during which time I have gained more information, and have considered the friendly and unfriendly suggestions made by critics. I am now in a better position to lay the question fully before the judgment of readers. I am only following the wise example of infinitely greater men by admitting weakness in some past work. Some of the verbal resemblances on which my work was based seem at present (if ever) to be incapable of proof; but the general result of my study has been to confirm my previous impression. I am now able to produce a remarkable and connected mass of facts, which I believe will cause the subject to be considered well worthy of deep attention.

The first point to be considered is, were the Polynesians autochthonous in the islands of the Pacific? If they are the true "children of the soil" there is little more to be said on the subject of their knowledge of cattle, since there seems to be no geological or other scientific evidence yet discovered of the existence of cattle in the South Seas before the advent of the Europeans. If we consider the "sunken continent" theory, it is evident that the cattle did not succeed in getting to the summit of the hills (the present islands) as swiftly as the moa, &c. The native traditions are unanimous as to their migration hither; and, although I am by no means a believer in the verbal inspiration of every native legend, I hold firmly to the general tenor of the stories telling of their comparatively late entrance into the Pacific. The Polynesians, according to tradition, arrived in canoes—a fact which would almost preclude the possibility of their having brought any large animals with them. We have, however, allusions in their old songs and traditions to animals of which no relic can now be found. Little has been yet done in collecting such allusions to olden times, and the hours are fast slipping away

in which such collections can be made;* but a few interesting relics have been preserved—sometimes almost unintentionally—by early writers on the Islands. Mr. Mariner, who was shipwrecked at Tonga, and was a prisoner there for many years, before the arrival of the missionaries, made it his pleasure after his return to England to compile a vocabulary and to describe the people among whom he had dwelt so long.† A wonderfully correct and interesting work his unusual powers of observation and memory enabled him to produce. He tells us, concerning their variety of songs and dances (choral dances), that some of them are called *Hamoa* (Samoa), but that one variety, the *Nuha* fashion of singing, is always in Tongan; and continues,‡ "The poet describes, among other things, the animals belonging to the country [*Papalangi* = the name of the place Europeans are supposed to come from, and stands for Europeans themselves], stating that in the fields there are large pigs with horns, that eat grass." It is certain that the Polynesian word *puaka*, used now (and at the time of the first discoverers) in the sense of "pig,"§ had in former times a much wider acceptance, as "large animal," and has been applied to the pig as "the" animal *par excellence*, because the only large animal surviving. The word is thus used (as "animal") in the ancient "Deluge Chant" of the Marquesas, where, in describing the entry of the different creatures into the ark or vessel, the expression is used, "*Mea pitiki i tahuna te tai o te puaa,*" "To tie up in couples the various kinds of animals."‖ The word *puaka* was generally applied to cattle, horses, &c., on their introduction by Europeans, as, Tahitian, *puaahorofenua* (land-running animal), a horse; *puaaniho*, a goat, &c.: but it was sometimes applied formerly even to men, as *puaahuaira*, an undaunted, fierce, athletic person. Its proper use seems to have been that *puaa* (*puaka*) means all hoofed animals, while *uri* (*kuri*) is reserved for all quadrupeds not having hoofs (except the rat). In Hawaii, *puaa*, as "animal,"

* New Zealand, Mangaia, and Hawaii have done best in this way. Tahiti (perhaps most interesting and wonderful in kingcraft and priestcraft) is almost unrepresented; but Miss Teuira Henry has possession of the documents collected years ago by the earliest missionary student of folk-lore, and her valuable work will soon be forthcoming.

† "The Tonga Islands," by W. Mariner. 1818.

‡ *L.c.*, ii., p. 310.

§ The Maori word *poaka*, for pig, was probably given them by the Tahitian interpreter, Tupaea, who was with Captain Cook when he gave the New-Zealanders their first pigs. Had the Englishmen given a word they would probably have said "pig," not "porker," and the Maoris would have called the animals *piki*.

‖ This ark in the Hawaiian "Deluge Song" is called *Waa* (*vaka*, *aka*, *waka*, &c., of different Polynesian dialects), or, in its full title, *Waa-halau-alii* (in Maori letters = *Waka-wharau-ariki*), the "Extended Ship of the Lord."

was applied sometimes to human beings: *puaaohi*, name of children whose father has gambled them away; *puaakunulaai*, a woman gambled away by her husband. One of the great Hawaiian *kupua* (wizard; Maori, *tupua*) was *Kamapuaa*, "the son of the *puaka*" (*tama-puaka*), who was the child of Hina and Kahikiula. This name (Maori = *Tawhiti-kura*), "The red one from afar," shows that this *puaka* was of a reddish colour.* *Kanepuaa* (*Tane-puaka*) was the god of husbandry, and of him the ancient proverb says, "*He akua kowaa o Kanepuaa*," "A furrow-making god was Tane-puaka." Primarily, doubtless, the furrow-making animal was a pig (Latin *porca*, (1) a sow, (2) a ridge between furrows†); but it could hardly be applied to an animal used in the name of the god of agriculture unless the animal was in use for purposes of tillage. There are many legends in Polynesia as to the conflicts of men with *puaka* which would certainly seem to imply a knowledge of a different beast from the friendly porcine pets of the South Sea Islanders.

Although I consider the Polynesians not to be aborigines of the Pacific, still their immigration must have been in a very ancient and prehistoric epoch. The genealogies are not trustworthy beyond a certain limit, and, although the evidence to be found in one island may confirm that of another as to the existence of certain real personages, when we get to *Atea* (daylight), *Atua* (god), *Tawhito* (ancient), *Kore* (nothingness), &c., we are evidently among a class of ancestors whose generations are likely to be unreliable as to time and dates. An immense period has evidently elapsed since the advent of the Polynesians into the Pacific, and it would be perhaps the most wonderful thing in the world if they had handed down by oral tradition complete stories relating to their life in other climes and under different conditions. The old has given place to the (comparatively) new; the scenes, incidents, and creatures they lived amongst in ancient days have faded from the memories and traditions of men utterly unable after centuries of existence under altered conditions to conceive the old life or the old environment. The knowledge of the life on the great plains where the fathers of the Aryan stock fed their herds has passed as completely from the knowledge of the fair Polynesian as from the memory of the English peasant; but the languages of both bear the ineffaceable impression of the old life to an extent only to be understood by one who searches very diligently. To a pastoral people their cattle are their all (as I have quoted at head of paper)—food, beverage,

* *Kamapuaa* was worshipped as a god. His wife is Pele, the goddess of volcanoes, whose home is in the great crater of Kilauea.

† The English "balk," or "bauk"—perhaps a corruption or another form of *porca*.

clothing, vehicles, cordage—nay, even their good and evil spirits. In modern Australia, a land of flocks and herds, we hear of men on up-country stations who can do nothing but "talk bullock;" and so all men did to a great extent in days when both word and idiom had origin in cattle-speech.* As the Sanscrit word for "cow-herd" passed into the meaning of "king" and "chief," as the Latin word for "hide" became "shield" and "tent," as "cattle-yard" became (as *court*) the name of a palace, so by slight and imperceptible gradations the old pastoral sense became buried under more modern significations, and is lost till the labours of etymologists trace the words back to their origin. In Polynesia the loss of large cattle for countless centuries has caused the early pastoral words to become obscure and overlaid by newer meanings, but I believe that I can show the primal meaning to be still distinctly traceable.

The Aryan or Indo-European forms of the words for cattle which I shall compare with Polynesian are *taurus* (*tur*, *stior*, &c.), cow (*gau*, *cu*, *chuo*, &c.), ox and *vacca* (*vaha*, *ὄχος*, *vach*, *ochs*, &c.), and *bos* (*bo*, *boo*, *bw*, &c.). The Polynesian words are *taura*, *tau*, *tara*, *kahu*, *kau*, *ngau*, *kai*, and compounds.

I must digress for a few words. I believe that there has been either a broadening sound added to the Indo-European vowels (particularly to the most important, the *a*), or else the Polynesian has lost the power of pronouncing final *r* after a vowel. This broadening sound is heard in modern English as a vulgarisation: Maria and Jemima become "Mariar" and "Jemimar." The Maori language suffered much at the lips of new-comers until a regular form of writing was made classical by the missionaries. In the report of the New Zealand Company's committee the *rata* (tree) became "rattar," the *tawa* (tree) "tower." Herman Melville, in his romantic little book on the Marquesas,† uses most laughable forms of this error. *Ama* (cooked bread-fruit) is *amar*, *manu* (bird) is *marnoo*, *atua* (god) is *artua*, &c. In the unknown centuries which elapsed before the Aryan languages were written down, it is probable that many *a* sounds were thus broadened. Or the true *r* sound may have been lost in the South Seas, as in many cases it was lost in Sanscrit, by the softening into the Visarga *h*, or as Sanscrit words softened in Prakrit (*akka* for *arka*, *vagga* for *varga*, &c.). That I shall have to compare some words having the pure Polynesian *a* (ah) with words having the Aryan *ar* is my excuse for thus digressing.

I will take as my first instance the word *bo* (bos, &c.),

* For ancient use of expression "talking bullock" see Bible (Apocrypha), Ecclesiasticus, xxxix., 25.

† "The Marquesas Islands," Herman Melville.

ox, bull, cattle. This word is considered by philologists as equivalent in Greek, Latin, &c., to the *gau*, *go*, *kuh*, *cow* word of Sanscrit and Scandinavian. The change of *g* to *p* is rather an unusual one, and I will consider "bo" and "cow" as separate words (at first), although the separation, in sense, will not be material to the argument. The Tongan word *bo*, meaning "night," &c., is pronounced as *po* in most of the other Polynesian islands, and I shall use the *p* form as the most generally received, especially asking that it should be borne in mind that *b* is probably a late letter in Aryan speech.* In the Maori of New Zealand *po* means — (1.) (A mythological word hard to define.) Origin; the potentiality of the material universe; a darkness holding light and all else hidden within it. (2.) Hades; the shadow-land; the place whence comes the spirit of the new-born child, and to which the spirit of the dead man returns. (3.) A season, or space of time. (4.) Night, darkness. (5.) The night, by which (instead of days) periods were counted.† The cosmogony of the Maoris commences with Po — Te Po, then Te Po-teki, then Te Po-terea, &c.: from these in due course are born *Ata* (morn), *Ao-tu-roa* (abiding day), &c.‡ "The great mysterious cause of all things existing in the cosmos was, as he (the Maori) conceived it, the generative power. Commencing with a primitive state of Darkness, he conceived *Po* (= night) as a person capable of begetting a race of beings resembling itself."§ This is the mythological development natural to man, and is so stated in almost every ancient cosmogony. The powers of Darkness were first. The Edda makes Day the child of Night.|| In the Rig-Veda (iv., 14) Indra throws his adversary into the "black abyss of night, into the birthplace of this sky."¶ The first principle of the Egyptians (according to the Platonist Damascenius) was inconceivable Darkness, whence Light was born. In the Izdubar legends of Babylon, the great goddess Ishtar is called "She who is Darkness, the Mother, the Producer of the Dawn, she is Darkness." The dread and fear of the dark was the first impression before which the simple hearts of savage men bowed down. But this superstitious fear was translated into words of cattle-speech (their only speech) by men when they first gained

* "Introduction to Greek and Latin Etymology," Peile, p. 126.

† In old Aryan fashion—fortnight, se'nnight, &c.

‡ For varying genealogies, see Shortland's "Maori Religion," p. 12; Taylor's "Te Ika-a-Maui," 110; Grey's poems, 268.

§ Shortland's "Maori Religion and Mythology," p. 10.

|| Grimm, "Teutonic Mythology," ii., 785.

¶ See Max Müller's "Lectures on Origin and Growth of Religions," p. 283.

language by passing from the solitary hunter stage into the gregarious pastoral stage. Everywhere in the ancient stories (except in Hebrew, as we understand it), "Cow of Heaven," "Bull of Heaven," "Primeval Ox," "Cow of Earth," "Mother-cow," "Goddess-cow," "God-bull," &c., are met with in prayer and praise. If Darkness was the first deity, holding the generative power (as among the Maoris), then this person was certainly called "the Bull" in the oldest Aryan religious hymns. The Zend Avesta, the sacred books of the ancient Persians ("fire-worshippers" though we call them), contain many allusions to this bovine first principle. "Hail, holy Bull! Hail to thee, beneficent Bull! Hail to thee who makest increase!" &c.* "Up, rise up, thou Moon, that dost keep in thee the seed of the Bull!"† "To the only created Bull."‡ In the Persian mythology *Geush urvá*, "the universal soul of earth," means literally the "soul of the cow." (See Haug on Gatha Ahunavaiti, in "Essays on Sacred Language of the Parsis," p. 148.) Concerning Egypt we find that "the Great Mother in her primordial phase was the 'Abyss in Space,' and the earliest recorded beginnings of time are with the Bull and the Seven Cows."§ In Greece the same idea prevailed. The Argolic name for Dionysius as the Sun-god was "Bougenes" (Ox-sprung). He is called "bull-faced" in the Orphic Hymn. Tauropolos is "the Kosmos considered as alive and animated, replete with motive life-power. This is the kosmogonic bull-cow." "The Bull: This animal in its widest symbolical sense represented the active energising principle of the universe."|| This bears out the idea of Pictet as to the prominence the cow or bull took in the myths as well as the lives of the Aryans and men leading the primitive life.¶

Is this *Bo* (Irish *bo*, Latin *bos*, &c.), of the primeval Bull, the primeval *Bo* or *Po*, the "night" of the Maoris? Darkness was connected with the idea of the black Bull before the powers of Fear and Night had been succeeded by the powers of Light—before the great Sun himself became "the Bull of Heaven." In our own English sayings we find "The black ox has trodden on his foot"**—meaning, "Trouble has come

* "Vendidad," Fargard xxi.

† *Id.*

‡ Sirozah i.

§ See Massey, "Natural Genesis," ii., 4.

|| "The Great Dionysiak Myth," Brown, pp. 42 and 187.

¶ "Ce fait reçoit une nouvelle évidence de ce que l'animal domestique, source de tant de bienfaits, était rattaché par toute sorte d'images et de mythes aux phénomènes de la nature et aux croyances religieuses."—Pictet, "Les Origines Indo-Européennes," ii., 87.

** "Dict. Phrase and Fable," p. 94.

to him." Again, "bull's noon" is an old English expression for "midnight."*

In the creation, as spoken of in the Bundahish, the Cow is cut in two. This is the Cow called in the Avesta the Geush (Yasna 29), answering to the Sanscrit *Gaus* and the Greek *Gaea* as applied to Earth. According to the Gatha Ushtavaiti, the "Cutter of the Cow" is the term applied to the Creator.† This is the cosmic Cow spoken of in the ancient Welsh poem: "Without the stall of the Cow, without the mundane rampart, the world will become desolate." Loki, the Scandinavian deity of evil, had to dwell as a cow eight months on earth. In Assyria the most ancient Bull was an image of the Swallower in the mouth of Hades, the nether world, which swallows up the sun as a two-headed Bull. In Phenicia the god of the beginnings was the consort of *Bau*, the Void. In Egypt the *Bau* (Bo?) was the opening of the tomb, the abyss. In Finland *Pohja* was "the place of spirits." Pluto, the god of the lower world, received the black ox as a sacrifice. In the Vedic rites of burial (*Ghyasutras*) a black cow accompanied the dead, and, the animal being slain, the corpse was wrapt in the hide before cremation. In the Brahmanas the death-river is called *Vaitarani*: in this the souls of the wicked are engulfed; but the good souls come to the land of the Pitris (Fathers) if a black cow is sacrificed at the funeral and another twelve days after death. In Scandinavia, when souls arrived at the death-river (*Giöll*), the soul of the dead man, if in life he had given cows to the poor, was met by these cows and safely ferried over. In the Norse legends of Creation the cosmic cow Authumbla licked the salty ice-rocks and produced the first giants, *Börr* and *Buri*.‡ I have one direct proof of the actual expression of "night" and "cow" being the same in meaning, where, in the Rig Veda, the horses of Indra are "bright as suns, who lick the udder of the *dark cow, the night*."§

I must return again to the cattle-deity subject when treating of the word "cow;" but I think I have quoted sufficient evidence to show that the bull (or ox, or cow) was used constantly in ancient times as a personification of the Abyss, of Death, of Darkness, and of the generative power passing from darkness into the birth of life—from *po*, the night, into *ao*, the light.‖

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* Wright's "Provincial Dict." and Charnock's "Glossary of Essex." Hawaiian *kau* = midnight.

† See Haug, *l.c.*, 165.

‡ Maori *po*, night; *pouri*, darkness (?).

§ See Max Müller, "Chips," vol. ii.

‖ Cf. Hebrew *aor*, light. *Aor*, *aur*, &c., were names of an ancient deity of the atmosphere in Asia.

It is probable that the Polynesian, deprived of the living animal, kept this form of the cow-word chiefly for mysterious ideas engendered of darkness—that is, of the simple word (*po*), although in many compound words, clear as the agglutinated Polynesian vocables show formation, no possible twist of sense can make the "night" meaning of *po* seem reasonable. There are words like *po-haha*—ripped up; *po-huhu*—swarming, in crowds; *po-ka*—to pierce; *po-nini*—to have a red light, to glow; *po-whiri*—to whisk; *po-pō*—to crowd around, to throng; *pōpō*—to pat with the hand, &c. What have these to do with night or Hades? And what mean the names of the first great Po's descendants—Po-tuturi, Popepeke, &c.? *Tuturi* means "to kneel," and *pepeke* "to leap." All these are probably cattle-words. It will be noticed that I have spoken of the cow, bull, ox, &c., indifferently: these words constantly shift sense in all ancient languages; it is supposed that there was no verbal gender in primitive Aryan. Sanscrit *go* (*gaus*) is ox, cow, constellation Taurus:* Irish *bo*, a cow: Latin *bos*, an ox, bull, or cow; *taurus*, an ox; *taura*, a barren cow: Welsh *buw*, a cow; *bwla*, a bull: Greek *βοϊκός*, belonging to a bull or cow.

As the word *po* seems to have been retained in Polynesian for the mythic sense, so *kau* appears to have taken a more practical use. Let us attempt to find its etymology—not in the inflected languages, with their thousands of years of overgrowth, but in the most primitive dialects we can find. Professor Max Müller, in his "Stratification of Language," gives the Chinese word *ngau-u* as "cow-milk" (*ngau*=cow). In Maori the word for milk is *waiu* (*wai-u*), "breast-water." But the *ngau* for "cow" compares with a Polynesian word *ngau*, to chew, to bite (gnaw); and, altered as this word may have been in the long process of time, still, as *gau, gao, kuh, chuo* (forms of "cow"), it still has its origin in the "ruminant" idea. Etymologists have hitherto considered "cow" as a derivative from $\surd$GU "to bellow;" or, rather, reversing this process, they have been led back to the root by this and similar words. To men in the "hunting" stage, the bellowing sound would probably be the most distinctive attribute of the bovine species; but when the pastoral life superseded that of the hunter the fact of cattle "chewing the cud" became too deeply associated with this word not to cover the sense of "bellowing." (Concerning the lowing noise, I shall speak more fully under the root MU.) I must remind you that *ng* and *k* interchange in Maori, as in all Polynesian and European languages. The *ngau* (*kau*) words in Polynesian are as follows: Maori, *ngau*,

* The Hawaiians call the Taurus constellation (or, rather, Aldebaran) *kao*.

to gnaw; Samoan, *gau*, to chew sugar-cane, &c.; Hawaiian, *nau*, to chew, chank; Tongan, *gau*, to chew the juice out of anything; Marquesan, *ka-kahu*, to bite; Mangarevan, *gagahu*, to bite; Rarotongan, *ngau*, to chew. If this idea of chewing had no parallel in the Aryan languages there would be little to be said; but there is one most noticeable affinity. In Maori *kauwae* means "the jaw."* The English word "to chew or chaw" was *chawe;* Old Dutch, *kaauw-en*, to chew; German, *kauen*, to chew; Old High German, *chuiwan*, to chew (*chuo*, a cow); Old Dutch, *kauwe*, the jaw of a fish;† Danish, *kæve*, a jaw (cf. Borneo, *jawai*, face, and Malay, *jawi*, cattle). Skeat ("Ety. Dict.") says that *jaw* (also spelt *chaw* and *jower*) is formed from the verb "to chaw;" again, *jowl* is from *chaul*, whose older form, *chauel*, is evidently a form of "chaw."‡ The Scottish *cow*, "to eat up as food" (Jamieson, "Scot. Dict."), brings me to another form of the word (as I believe)—that is, the Polynesian *kai*, "food," "to eat." A curious and unexpected light is thrown upon this word by Mr. Colenso§ when he says, "A very old meaning of *kai*, as a noun, is movable property, possessions, goods, chattels—valuables in the estimation of the ancient Maori." Note here the term *chattel*.‖ The English word *chattel* itself means "cattle." The Scottish word *kye* or *ky* (pronounced nearly as Polynesian *kai*) is cows. *Ky*, cows; *ky-herd*, a cow-herd (Jamieson). Thus it is used for cattle collectively, as the Polynesians used it for food generally. It may be that *ky* or *kai* is not a true plural (the plural proper being *kine*), my reason for throwing doubt upon the original form (if Aryan had a verbal plural) being that Bopp ("Comp. Gram.," i., p. 136, note) remarks that Old High German *chuo*, "cow," has genitive *chuoi*, "where the *i* does not belong to the case designation, but to the here uninflected base." (Cf. Icelandic *kyr*, a cow; dat. and accus., *ku*.) Perhaps the *i* belonged no more to the plural number than to the genitive case. In Hawaiian, *ai* (*kai*) meant not only food, but property generally (see Lorrin Andrews's Dict.). In Tongan *kai* meant "food," but *kakai*, "people, population;" the Samoan *'a'ai* (*kakai*), "a

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* Samoan, *'auvae* (*kauvae*), the chin; Tahitian, *auae* (*kauae*), inner part of lower jaw; Hawaiian, *auwae* (*kauwae*), the chin of a person; Marquesan, *kouvae*, the chin; Mangarevan, *kouae*, the jaw.

† *Kauwae-roa* (long-jaw) is the name of a New Zealand fish—syn., *hapuka*.

‡ Kluge ("Ety. Wort.") gives the German *kauen*, "to chew," as related to γεύομαι: if so, any connection with a √KAF becomes doubtful.

§ "On Nomenclature," by W. Colenso, F.R.S., Hawke's Bay Philosophical Institute, 10th July, 1883.

‖ Scottish *chattel*, "to chew feebly." Jamieson ("Scot. Dict.") says, perhaps a diminutive from *kauwen*, "to bite."

town, a village." Another Maori form of *kai* is that where it is used as a prefix applied to denote an actor in any business, as *mahi*, "to work," *kai-mahi*, "a worker," &c. The word used thus for a person seems to interchange with *kau*, as in *kaumatua*, "an adult," a mature person (*matua* = grown-up, mature); and with Tahitian *aufenua* (*kau-whenua*), the permanent inhabitants of a place (Tongan = *ka-kai*). The word *kau* in Polynesian has one sense of "a troop" of persons: the Samoan *'au* (*kau*), a troop of warriors, a class or company, a shoal of fish; *fa'a'aumea* (*whaka-kau-mea*), to associate together, to hold in common: Tahitian *autahua* (*kau-tahunga*), a company of priests: Tongan *kau*, the sign of the plural number; *kauga*, an associate; *kauvaka*, the crew of a vessel: Futuna, *kau*, a multitude, troop; *kakai*, people; *kaugao*, the molar teeth. Mariner ("Tonga Islands," vol. ii.) gives, in his curious English spelling, the following meanings: *Cow-fafine*, a female companion; *Cow-nofo*, a servant, an inmate, a family; *Cow-tow*, an army. Thus the sense of *kai* as property, chattels (cattles), anything in large quantities, doubles with *kau* as meaning a troop, a herd.* The pastoral people had little to lose by theft except cattle. In the Vendidad *thief* = "cattle-lifter;" the Icelandic *ku-drekkr* (cow-sucker) = "thief." So in Maori we find *kaia* (*kai-a*), to steal, where *a* is the verb "to drive."†

It may be that the simplest form of *kau* (as *go*, *gao*, *zao*, *kuh*, &c.) can be found on a root KA. I do not think that *kai* is the primitive Maori word for food, but *ka*; as we have not only *kai* (*ka-i*), but *kamu* (*ka-mu*) and *kame* (*ka-me*), food. When we consider that the Sanscrit *go*, which means at once ox, cow, country, earth, hide, &c., is *gaus* (*ga-us*); Anc. German *gawi* (*ga-wi*), Anc. Saxon *ga*, Mod. German *gau*, Old Friesic *ga*, all mean "district;" Greek γαῖα, the earth ("But if we reach Achaian Argos, udder-soil"—"Iliad," book ix.)—it seems probable that GA or KA, and not GU, is the primal form.‡ The Samoan *'a'ai* (*kakai*), village, suggests the Russian *gai*, the Lithuanian *go-jai*, pasturage. The Egyptians had the forms *kau* and *kai* for "cow;" so the words seem transferable in many languages. Kakau introduced worship of animals into Egypt—probable of Bull Apis. The English word *jam*, to squeeze, is the same word as *champ*, to chew: cf. the Maori *tame*, to eat, to smack the lips, food (cf. *kame*, to eat); Welsh *tam*, a morsel, a bite; Cornish *tam*, a morsel,

* Cf. Gaelic *caithim*, I eat: Welsh *cicai*, a feeder on flesh; *cnoi*, to gnaw: Manx *caignee*, chewing.

† The Sanscrit *aj*, to drive: cf. Latin *ago*, to drive cattle; ἄγω, I carry away, take captive. Connected with *vak*, or *vah*.

‡ Cf. Kourd *gha* and *ghai*, Afghan *guai*, Albanian *ka*, bull.

a bite; Slavonic *yam*, I eat; Sanscrit *cham* and *jam*, to eat. The accusative of Sanscrit *go*, a cow, is *gam*.*

The *h* in Polynesian is not a permanent letter, being introduced in Tongan where not in Maori, and absent in Rarotongan altogether. *Kau* and *kahu* are used apparently indifferently in interchange, but *kahu* is reserved generally for the meaning of "clothing," "to dress." In Sanscrit *gau* meant "hide" as well as "cow;" and the Aryans were only clothed in leather or skins.† It is probable we should find many allusions to this subject if we could get the radical meanings of some of our obsolete words;‡ but in the matter of dress new and local names are continually being invented and superseding those used a short time before. *Kau* or *kahu* (Tahitian *aahu*, to bite (*ngahu*), shows the connection) is used all over Polynesia for "garment," "clothing," "covering," whatever may be the local names for particular dresses. If to these meanings of *kau* as food and clothing we add the words for "carrying," we have a curious series of coincidences.

The Beast of Burden.—The means of conveyance among pastoral people must of necessity (especially at first) have been by means of animals, and probably by horned animals.§ Not only must the horse have been of far less utility generally than the ox, but, historically, it is almost certain that the horse was domesticated later. It is doubtful if the horse was brought into Europe at all by the Aryan immigrants. Sir J. Lubbock, *re* evidence gathered in the ancient tombs, writes,‖ "The horse was very rare, if not altogether unknown, in England during the Stone Age. . . . The teeth of oxen are so common in tumuli that they are even said by Mr. Bateman to be 'uniformly found with the more ancient interments.'" And again¶: "the sheep, the horse,

* The Paumotu vocabulary gives us *kakai*, to gnaw, nibble; *kai*, *kati*, and *taruhae*, food, to eat. When two vowels come together in a Polynesian word there is probability of a lost consonant; thus, it is possible that *kati* is original form of *kai*. But *kati* means to chew (in Maori, to nibble): thus we get to the "gnaw" word *ngau*, which = *kau*. But *taruhae*, to eat? *Taru* means "grass," and *hae* "to tear"! Again, we have *gahu-gahu*, "to chew, ruminate (!), think upon."

† Professor Sayce, in his address to British Association (*Nature*, 29th September, 1887), says that the speakers of the parent Aryan language had only the skins of wild beasts to protect them from the rigours of winter, and nothing better than stone weapons with which to ward off the attacks of animals. See also Herodotus, "Clio," 71.

‡ Cf. Icelandic *bufe*, milch-kine; *buningr*, dress, clothing.

§ As to oxen as draught animals, we have carvings showing the use of ox-carts, &c., in Assyria and Babylon; oxen drew the cars of the Frankish kings; and Grimm tells us that oxen were used for war-chariots till late in the Middle Ages.

‖ "Prehistoric Times," p. 115.

¶ *L.c.*, p. 182.

and the reindeer being entirely absent, and the domestic cat not having been known in Europe until about the ninth century." We know that in Africa not only is the pack-bullock used for carrying burdens, but also for riding purposes, the animal being guided by reins attached to the horns, which are made artificially tender at root to feel the touch of the rider. That the Polynesians were once acquainted with some animals of the kind seems almost the only explanation possible for some of their words, which run in changes on *kau* and *vaka* (*vacca*). The English word "vehicle" is from Latin *veho*, which meant primarily "to carry or convey *on the shoulder*." "Hence *vacca*, properly a beast of burden."* Vehicle is from an Aryan root WAGH, to carry; whence also Sanscrit *vah* (Skeat). But in no Aryan tongue can the root *vah* be found more purely in use than in the Polynesian *vaha*, to carry.† As a variant from *vah* to *kau*, we have the Fijian *kaukau*, to carry. The Maori has only compounds, as *pikau* (*pi-kau*), to carry on the back, pick-a-back (Williams's Dict.).‡ *Kauamo* is a litter, a bed arranged between two poles; *kauhoa*, to carry on a litter—perhaps reminiscences of something resembling a palanquin preceding the wheeled chariot. The Sanscrit word *vah*, to carry, is acknowledged to be the equivalent§ of the Greek ὄχος (*ochos*), meaning "anything which bears, a carriage;" ‖ ὀχέω, to carry, to let another ride, to mount; ὄχος (for Ϝοχος) is the form related to *vah* (*vach*, *vacca*, &c.); but there was probably a primitive radical unity between *ox*, *vach*, *gau*, &c.

Whence came the Aryans? According to the accepted theory¶ and the evidence of the sacred writings (Vendidad),

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* Smith's "Lat. Dict.," 1877.

† Samoan, *fafa*, to carry a person on the back, to convey generally; Tahitian, *vaha*, to carry a royal personage on the shoulders of a man; Maori, *waha*, to carry on back, &c.

‡ "Pick-a-back" is a word, or idiom, for which some Europeans make frantic struggles to find an etymology. Richardson's "Etym. Dict." suggests "pitched on the back." "Pig-a-back" is also tried; but the etymology of "pig" is unknown, except that it *may be* related to Scandinavian *pige*, a girl! The Swedish dictionary gives *pick-och-pack* as "bag and baggage;" but, as *pack* means "a mob" (as in English, "pack of hounds"), it is a probable derivative of √ PAK, originally to tie up, tether, as a cattle-word (whence Latin *pecus*, *pecunia*, &c.), and then to tie up as a load or pack for a pack-ox. Cf. the Maori *paki*, a girdle; *pakikau*, a garment.

§ Bopp, "Comp. Grammar," i., 15.

‖ But not necessarily the *body* of the carriage. τρόχαλοι ὄχοι ἀπήνης, "the round bearers of the chariot"—*i.e.*, the wheels. (Euri., Iph. in A., 146.)

¶ I am acquainted with the Lithuanian theory of which Professor Sayce is so distinguished an advocate; but that theory is yet on trial, while so many eminent philologists and mythologists have located the "Airanya Vaego" in Central Asia that I follow them humbly. So far

the habitation was near the Belurtag and Samarcand, on the plateau of Pamir, at the sources of the Oxus and Jaxartes. This is *the* Pamir—called now Bam-i-duniah, or "Roof of the World." The Oxus valley runs as far as Issar, where its height is 10,000ft. above the sea. The mountains above the lake on Pamir are 19,000ft. high at the place where the Oxus takes its rise. No wonder, then, that the sacred traditions of the Aryans say that in their birthplace—the "Airanya Vaego" —"there are ten winter months there, two summer months, and those are cold for the waters, cold for the earth, cold for the trees. Winter falls there with the worst of its plagues."* "The Oxus appears in the traditions of the Parsi books under the name of Veh-Rúd, in some form of which originates the classical name which we find it most convenient to use, and also, it may be, preserves that of the names of territories and tribes on the banks of its upper waters, such as Wakh-an, Waksh, and Washjird—names also, no doubt, identical in formation, if not in application, with the classical Oxiani, Oxii, and Oxi-petra. [*Note.*—This latter form, Waksh, seems to have originated 'Oxus,' whilst Wakh seems better represented by 'Ochus.'] "† In an account of a remarkable mission from Constantinople to Transoxiana in A.D. 568, Colonel Yule says, "The Byzantine ambassadors, on their return to Europe, came, we are told, to the River Oech, in which we have probably the latest mention of the Oxus by its name in the primeval form (Veh or Wakh). . . . The old Chinese pilgrims to India, whose route lay this way, speak of principalities that must have lain in this region. Such was the State of Uchcha (of which a trace seems to remain in the Uch or Vachcha valley)." We have the authority of Pococke for saying that the Ookshas, the tribe of the Oxus, had wealth of oxen; that Ookshan seems only the crude form of *ooksha*, "an ox."

Near this land (bounded to the north by Mount Taurus), the names of whose tribes, states, rivers, &c., thus seem to have borne so long the traces of their ancient herdsmen owners, we find described the following scene:‡

as I can ascertain, the true affinities of the Polynesian speech are less with Asiatic tongues than with the dialects of north-west Europe—not because it was probable that the Polynesians were dwellers in north-west Europe, but because the Celts and Scandinavians were (in my opinion) an earlier and ruder wave of the western migration than the Greco-Italian peoples, and their *short* words have remained, like Maori, almost uncorrupted for ages.

* Vendidad, Fargard i., 4.

† "Journey to the Source of the River Oxus," Captain John Wood. Preface by Colonel Yule, C.B., from which part above quotation.

‡ On the Indus; but the Oxus and Indus were formerly supposed to be the same river. See Bundahish, xx.

"It is a diverting sight to witness a herd of buffaloes swim the river: all is noise and confusion, and considerable tact is necessary on the part of those who command the movement. A herdsman bestrides a bundle of dry grass, seizes a sturdy animal by the tail, and on this singular carriage takes the lead. The other buffaloes follow, while laggards, and any that may be vagrantly inclined, are driven up to the main body by the cudgelling of men in the rear. The herdsmen are armed with long light lances* for the defence of themselves and their charge."† Again, speaking of buffaloes, "Numbers of these huge brutes lay at the entrance to almost every creek, enjoying the luxury of mud and water, with only perhaps the tip of the nose or the curved end of a horn visible above the surface. . . . The buffalo, the animal which furnishes the principal supply, is milked in the evening, and only once in the twenty-four hours. . . . Perhaps a herd of cattle swimming the river were the only indication that the country was peopled." In another land, far away (the Philippine Islands), we notice how the habit of cattle is semi-aquatic. "The river-side is a pretty sight when the men, women, and children are bathing and frolicking in the shade of the palm-trees, . . . and when the boys are standing upright on the broad backs of the buffaloes, and riding triumphantly into the water. . . . The buffalo, the favourite domestic animal of the Malays, and which they keep especially for agricultural purposes, prefers these regions to all others. It loves to wallow in the mud, and is not fit for work unless permitted to frequent the water."‡ In Babylonia "herds of buffaloes here and there struggled and splashed among the reeds, their unwieldy bodies completely concealed under water, and their heads just visible above the surface."§ These quotations are sufficient to show that horned cattle, milch cattle, agricultural cattle, &c., not only loved the water, but were actually used for crossing streams. Had it not been for the witness of these travellers, we had never dared to connect the words for ox or cow with the idea of "swimmer." We must conceive the very reverse of a maritime people—a race dwelling on treeless plains, their

* Here we see the "herd" etymology of Maori *kau-kau*, a spear. Compare Anglo-Saxon *gar*, a spear; Icelandic *geirr*, a spear; Old High German *ker*, a spear; Manx *ga*, a spear. If the English word "to gore" is derived from *gar*, a spear (see Skeat, "Ety. Dict."), then it is almost certainly a cattle-word, being still mostly used for being "speared" on the horns of cattle. Cf. Sanscrit *go*, cow and arrow; Irish *go*, lance: while on the other form, *kai* (kye), we have the Irish *gai*, a spear; Goth. *gais*, a spear; &c.

† "Journey to Source of River Oxus," p. 35.

‡ "Travels in the Philippines," F. Jagor, pp. 43, 44.

§ "Nineveh and Babylon," Layard, p. 315.

only navigation confined to crossing rivers here and there, the herdsman holding the tail of the beast, or standing on its back.

Let us now consider two Polynesian words, *kau* and *vaka,* which I think are forms of *cow* and *vacca* :—

Maori—*kau*, to swim, to wade: *kau-kau*, to bathe. Samoan—*'a'au* (*kakau*), to swim: *'a'au*, to swim about: *'aupui*, to splash. Tahitian—*au* (*kau*), to swim. Hawaiian—*au* (*kau*), to swim, to float on the surface: *aau* (*kakau*), to swim dispersedly. Tongan—*kaukau*, a bath, a wash. Marquesan—*kau*, to swim; oil, grease.* Mangarevan—*kau*, to swim: *kaukau*, to wash one's-self with *fresh* water.

Maori—*waka*, a canoe; a medium of the gods. Samoan—*va'a* (*vaka*), a canoe; the priest of a deity. Tahitian—*vaa* (*vaka*), a canoe: *vaahuia* (*vaka-huia*), all the people within the prescribed limits of a district.† Hawaiian—*waa* (*waka*), a canoe. Tongan—*vaka*, a general name for all vessels that sail: *vakavakahina*, to be carried on the shoulders of another: *faka-vaka*, to handle; to cover or bind as books; the bindings of books; to make small pens or places for storing yams. Marquesan—*vaka*, canoe: *aka*, to float on surface: *vakaani*, a litter on which to carry chiefs in triumph (see Maori *kau-hoa* and *kau-amo*, quoted above). Mangarevan—*vaka*, a canoe, raft. Rarotongan—*vaka*, a canoe. It is a widely-spread word, and may be found in Melanesia as *faka*, *waga*, *ak*, *ok*, &c.; perhaps in Tagal (Philippines), *banca*, a canoe; and Malay, *wangkang*, a ship; Labuan, *boui*, to swim.

The remark concerning the crossing rivers holding by the

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* The Indo-European words ναῦς, navis, &c., for "ship," are referred to a root SNU, to float (Sanscrit *snu*, to ooze, flow). Except in Samoa, the Polynesians do not use the letter *s*, but the aspirate. If we wished to find *snu* in Polynesia, we must look for *hnu* with a vowel between *h* and *n*, because a vowel must follow a consonant in these languages. We find that in Maori the word *hinu* means oil, fat, grease: in Tahitian, *hinu*, *id.*; *hinu-hinu*, brightness, lustre; *faa-hinu* (*whaka-hinu*), to cause lustre or splendour, to make respected or honourable: Hawaiian, *hinu*, ointment, to anoint, smooth, polished, to slip or slide easily; *hinuhinu*, bright, splendid, shining as red cloth, glittering as polished stones; *ohinu*, to roast, as meat: Marquesan, *hinu*, to make sacred (*tapu*), to make certain things unable to be eaten by certain persons: Mangarevan, *hinu*, grease, oil. (It will be well to notice how the Asiatic idea of splendour runs with that of "butter," "grease," &c., the anointing oil of sacrifice—spoken of many times in the old sacrificial hymns.) The Persian *pinu*, milk, butter (Gr. πίνω, I drink?), may be compared here with Maori *hinu*, oil, and *inu*, to drink; Mangaian, *inu*, oil, and to drink. The first notion of swimming was apparently the swimming of oil upon milk or water (*hnu* or *snu*), later the swimming of the animal.

† The *vaa* here (*hui* is a collective plural) is not the Maori causative prefix *whaka* (which would in Tahitian be *haa* or *faa*), but *vaka*, in the sense of *kau*, a troop, herd—the *gau* or *go* of Aryan, as earth, district, pasturage.

tail of the ox throws light upon ancient practices as to dying men. "The Hindus offer a black cow to the Brahmans in order to secure their passage across the Vaitarani, the river of death, and will often die grasping the cow's tail as if to swim across in herdsman's fashion, holding on to a cow."* This probably explains why, in Maori, *waka* means "canoe" and "medium of a deity;" why the Samoan *va'a* (*vaka*) meant both "canoe" and "priest." This priest or medium shadowed the boat or sacred *vacca* which took the soul across to the gods—a meaning plainly shown in the Samoan word *va'aaloa* (*vaka-aloa*), "the canoe in which souls were ferried across to the other world." How widespread is this idea of the boat of death! We see Charon ferrying the souls of the Greeks across the dark river, and the souls of the Breton dead passing across in a boat to England.†

This mode of navigation was the first used in the treeless Aryan land—the *vacca* (cow), as "bearer," was the first *vaka* (canoe). But a further step was made as time went on. The boat was made from the *hide*—first as inflated in bags. In Layard's "Nineveh and Babylon" is a representation of "a *kellek*, or raft of skins, on the Tigris" (Plate XXXVI., fig. 1). Here a light framework of wood, with a house or tent thereon, is supported upon a number of inflated skins. This boat of to-day, so far from being a modern idea, was the ancient mode of conveyance thousands of years ago. At page 301 ("Nineveh," *l.c.*) the author says, "Merchandise and travellers descended the rivers upon rafts of skins." And at page 77 is an engraving of a bas-relief from Kouyunjik, an old Assyrian piece of sculpture, on which identically the same form of boat is represented—viz., of woodwork superimposed upon inflated hides (Plate XXXVI., fig. 2).

The next page shows an engraving of another Assyrian sculpture, having figures of single persons swimming across a river, each with an inflated skin as a boat (Plate XXXVI., fig. 3). To this day a similar habit of the dwellers in Asia may be noticed. In the "Journey to the Source of the Oxus," p. 64, we find, "Early in the forenoon they repair to the river or canal, and there, upon their *mussuks* (inflated hides), float and talk till sunset. I have seen in one group a father and two children, the latter on dried elongated gourds, clinging to their parent, who bestrode a good-sized *mussuk*. Close to them came two grey-haired men, apparently hugging each other, for they rode upon the same inflated skin, which, but for the closeness with which they embraced it, would soon have parted

* See Colebrook, "Essays," vol. i., p. 177б; Ward's "Hindoos," vol. ii., pp. 62, 284, 331 (quoted by Tylor); "Primitive Culture," vol. i., 427: also "Races of Mankind."

† For similar Irish legend see O'Donovan's "Irish Grammar," p. 440.

company. Next came sailing down an individual lying much at his ease between the four legs of a huge buffalo's hide, while boys moved in all directions, mounted as they could, some on gourds and some on skins."

Thus, then, *kau* and *vaka* had passed from the *animal* to inflated *hide*. From this form, doubtless, men went on to the discovery that the skin itself needed not to be inflated, but that, if bound to a framework in the shape of a hemisphere, it would buoy up the contents, if not buried above the water-line. Herodotus ("Clio," 94) says, "The most wonderful thing of all here, next to the city itself, is what I now proceed to describe: Their vessels that sail down the river to Babylon are circular, and are made of leather. For, when they have cut the ribs out of willows that grow in Armenia above Babylon, they cover them with hides extended on the outside by way of a bottom."* Thus the idea has grown from the living water-loving animal, the type of the "good swimmer," whose tail is held by the herdsman, to the "inflated hide," and then to the wicker boat covered with leather, used from Babylon to Britain.†

The journey of the westward-migrating Aryans was across the great continent of Europe, where, even had they been a navigating people, boats could not have been carried; but they surely had, in the herds which accompanied them in their slow irresistible movement onwards, their time-honoured means of crossing any rivers on their march.‡

The word *vaka*, for boat, has been retained in the European languages, although unrecognised, because disguised by the slight letter-change of *v* to *b*,§ and by the broad vulgarised *r*. We have it in English *bark*, *barque*, and *barge*. Professor Skeat ("Ety. Dict."), although noticing that "it is remarkable how widespread the latter word (*barque*) is," does not seem able to find the etymology, but suggests as possible the Egyptian *bari*, a boat. When we consider the Gaelic *barca*; Latin, Spanish, and Italian *barca*, boat; Danish *barkasse*, long

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* The Polynesian word *kili* or *kiri* ($\surd$ KIL or KIR), meaning "skin," seems to be related (in sound) to the name of these skin-boats. The boats on the Tigris (Pl. XXXVI., fig. 1) are called *kellek*, or *kilet*. The boat of the Ancient Briton was—Gaelic *curach*, Welsh *cwrwg*, a frame, a carcass, a boat (coracle). English, *keel*, a boat ("Merry may the *keel* row"); Anglo-Saxon, *ceol*, a ship (Teutonic base, *keula*); Malay, *kolek*, canoe; Persian, *kiraw* canoe, *kirep* ship; Anc. Slav., *korabi*, ship; Polish, *korab*, from *kora*, bark.

† Cf. (obsolete) English *cow*, a tub: Scottish *cowan*, a fishing-boat; *skow*, a small boat made of willow covered with skin (Jamieson): Persian, *kaurib*, a boat.

‡ Cf. Maori *kaku-papa*, a raft; Fijian *kawa-kawa* (*gava*), a bridge.

§ As Sanscrit *varvara* = *βαρβαρα*; *habere* becomes *avoir*. Latin MSS. often vary from *vixit* to *bixit*, *vene* to *bene*, &c.

boat; French *barque*, &c., it would seem to be unnecessary to go outside of the (acknowledged) Aryan languages to the Coptic *bari*. Probably *barka*, *baka*, or *vaka* meant the hide of *vacca*, the "carrying animal." Nay, even our word *bark* (of tree), of which the etymology is unknown, may be absolutely the same word as *bark*, a ship (cf. Sanscrit *valka*, bark of tree), in the sense in which the Maori word for "hide," "skin," also means "bark of tree." In Sanscrit *vaha* is "bearing," "carrying," as in Maori *vaha;* but *vahata* is an ox, *vahatu id.*, *vahala* a raft, a float, *vahitra id.*, *vahin* a boat, &c., *Vakshu* the Oxus River. It is a curious fact that Turner, who appends to his "Samoa a Hundred Years Ago" a comparative table of forty dialects, gives for "canoe" in very many islands *vaka*, *va'a*, *vaa*, &c., and then, for Hawaiian, *kau*, a canoe.*

Turning for awhile from the subject of bearing and swimming, what is the connection between "cow" and "voice"? (It may be the √GU, spoken of before, from the bellowing of the herd.) That these words are radically connected in some way is certain. Our word "voice" is (through Old French *voix*) from Latin *vox*, a voice. Skeat writes *uox*, a voice (the likeness to "ox" may be purely accidental, if there is such a thing as accident), from √ WAK, to resound, to speak. (Cf. Sanscrit *vach*, to speak.) But the Sanscrit *vach*, speech, voice, with variants *vak* and *vag* (as *vak-patu*, eloquent; *vag-isa*, an orator), is the name of Sarasvati, as the Goddess of Speech. She was the Sacred Cow,† the Mother of the Vedic poems, the Fount of Wisdom, "the melodious cow who milked forth sustenance and water." "That daughter of thine, O Kama! is called the Cow—she whom sages denominate Vach" (Atharva Veda). Here appears the link between the Polynesian *vaha*, to carry on the back, and *vaha*, the mouth, speaking, talking.‡

In the Gatha Ushlavaiti mention is made of "the imperishable cow *Kânyô-skereti*." Haug (*l.c.* 159), in a note, explains this as a myth-name of the earth, and as meaning "producing the two friction-woods"—the friction fire-sticks. The sticks for producing fire by friction are, amongst the Maoris, always spoken of by some word compounded with *kau:* thus, *kau-ahi*, *kau-ati*, *kau-noti*, *kau-rimarima*, &c. (whether related

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* The Aneityum (New Hebrides) word for canoe is *nel-cau;* while "tree" (Polynesian *ra-kau*) is *in-cai*. The Hawaiian form *kau*, canoe, is properly *tau*, of which I shall presently treat.

† Cf. the Cornish *cows*, to say; Egyptian *kau* or *ka*, to say.

‡ Maori, *waha*, to carry on back, the mouth: Hawaiian, *wahaa*, to talk: Mangarevan, *va*, to speak; *vaha*, to put in evidence: Marquesan, *vavaha*, to answer: Tongan, *fahafaha*, to go shouting: Malagasy, *vava*, mouth; *vavana*, loquacious.

by etymology to *rakau* (wood) or not), is the regular form for "fire-stick;" and I do not know any other explanation than by reference to the fuel-giver of the Aryan races.

Before quitting the "bearing, carrying" idea of *vah* I may perhaps be allowed to suggest the true etymology of Polynesian *vahine*, "a woman," "wife." In Maori *hine* means "girl" (*tama-hine*, daughter, &c.), and the *vah*, "to carry," meaning was understood by Mr. Taylor ("Te Ika-a-Maui"), who said that it arose from the native woman having unfortunately (in the savage fashion) to do all the heavy carrying of burdens. Monier Williams, in his Sanscrit Dictionary, gives *vah* as "to bear, carry, carry away;" *vahatu*, "nuptial ceremonies."* Our word to "woo" is from a root WAK (*vak*). Thus the Polynesian *vahine*, "wife," probably means not "one who carries," but "one who is carried off"—a reference to the universal ancient custom of carrying off wives by force.

Having thus shown that the words for food, clothing, carrying, stealing, &c., are in Polynesian reminiscences of cattle-words, I will now point out the important words having reference to "milking." That the absence of milch-animals for many centuries had its effect in narrowing down the number of these words is certain—indeed, no other result could be possible under the circumstances—but the form, and somewhat of the sense, were retained under the new character. The primitive forms of "udder," "teat," "*mammæ*," &c., are to be found in the South Seas. I think that any candid reader will, on learning the geographical distribution of the milk-words, laugh to scorn the dogmatic pretensions of those who try to draw a territorial line across any part of the Malay Archipelago or Indian Ocean and say, "Thus far shalt thou go, and no farther." First, "udder:" Latin *uber*, Sanscrit *udhar*, Gaelic *uth*, Irish *ut* and *uit*, Manx *oo*. (Root unknown. —Skeat.) We have in Maori a word, *u*, the breast of a female, udder, teat—*wai-u*, milk. It seems that this is the simplest and most radical form obtainable; it has been kept pure, and shows as the "constant" of the European variations. Tahitian *u* means milk, the breasts of anything that gives milk, to be moist or wet; *utau*, a wet-nurse (probably as *ukau*): Hawaiian *u*, the breast of a female, the pap or udder, to ooze or leak slowly:† Tongan *huhu*, the breast, the dug or teat of animals, to suck; *huhua* milk, juice: Samoan *susu*, the

* The Sanscrit *vaça*, *vaçaka*, obedient, submissive wife, probably = *uc*, of Latin *uxor*, wife.

† *Uu* = masturbation, to draw out as indiarubber. See, again, under "Teat." Cf. the Scottish *ure*, the dug or udder, with Polynesian (*ubique*) *ure*, *membrum virile*. Wright ("Provincial Dict.") gives old English *yure* or *yewer*, cow's udder; Chinese *yu*, milk—*ngau-u* = cow-milk.

breasts, the dug or teat of animals; *suasusu*, milk. So far Polynesian proper: this is sufficiently well marked. Passing outside Polynesia, we get Fijian *sucu* (*suthu*), to suck, the breasts, to be born; *kaususu*, a female that has just been confined: Malay proper, *susu*, milk: Kayan, *usok*, breasts: Java, *susu*, breast: Bugis, *susu*, milk. The European forms of "suck"—Anglo-Saxon *súcan*, Latin *sugere*, Swedish *suga*—compare with the Welsh *sugno* to suck, *sug* juice; the Irish *sughaim* I suck in, *sugh* juice. Skeat refers these to an Aryan root SU, to beget (whence is derived *sunu*, a son), but, when we find so many of these words meaning "sucking" and "juice"* duplicated with the same sense in Polynesian (above given), I think it may fairly be claimed that the idea implied by the root is a mother suckling rather than bringing forth. It will be noticed that the Fijian *sucu* means both to suck and to be born, but it stands apart (so far as I know) in this respect. The general idea is "moisture oozing forth," but especially milk oozing forth from the teat. The idea of giving suck to the young after birth is surely as old as the idea of parturition. In Maori a compound word *uwha* (*u-wha*) means the "female of beasts." Why? *U* means "teat," and *wha* means "four."† What four-teated animals did the Polynesians ever know in Oceania? Certainly neither the dog nor the pig answers to this description.‡ Returning to the idea of "moisture oozing forth," I turn to the Latin word *mamma*, the breast. In Maori we have *mama*, to ooze through small apertures, to leak: Samoan, *mama*, to leak: Tahitian, *mama*, to drop or leak, as thatch of house; *aumama* (for *kau-mama*), to chew food for a child; *aimama* (*kai-mama*), to eat food chewed by the mother: Tongan, *mama*, to leak, to chew: Marquesan, *mama*, to chew: Mangarevan, *mama*, to leak, to chew. Polynesians feed very young infants by chewing food and putting it into the babies' mouths. The Latin *mamma* means not only "the breast," but "mother"—two ideas closely related—and, although the word *mamma* for "mother" may be a mere sound-word coined from a young child's cry, and therefore not allied to "chewing," still the sense of "oozing," leaking, is in the Polynesian *mama* as in *susu* or *huhu* (*uu*).

"Teat:" This has been spelt in English in very many

* Skeat remarks ("Soul," in "Ety. Dict.") that the word "sea" may, as Curtius suggests, "be connected with √SU, to press out juice, which appears to be identical with √SU, to generate, produce."

† Tahitian *ufa*, female of brutes; Mangarevan *uha*, female, applied only to animals, &c., &c.

‡ The Maori *ua*, rain, shows that the Aryan universal image of the clouds being "the cows" of heaven, dropping fertility, was known to the Polynesians. Cf. the Cornish *cowes* = showers.

different ways—*teat, tit, titty, tete, tetle, titte,* &c.—but has European equivalents for each variant: Welsh, *did, didi,* and a second form *teth;* Italian, *tetta;* Spanish, *teta* (*atetar,* to suckle); German, *tütte;* Greek, *τίτθη,* a nurse;* Cornish, *tidi,* teat. In Maori we have a corresponding word in *tete,* as *whaka-tete* (*whaka-te-te;* whaka=causative prefix), "to milk." In its simpler form we find it as *whaka-te,* "to squeeze fluid out of anything;", thus showing it to be a synonym of *mama,* to ooze, and *u,* the breast.† Tahitian form *faa-te* (*whaka-te*), to draw out, as in milking, or to squeeze out the *ui* (yellow apple) juice; *fe-titi,* to gush out at high pressure; *fetee, id.*: Fijian, *titi,* to ooze: Malay, *tetek,* the breast. My Mangarevan-French vocabulary gives *kaiu* (*kai-u*) as = *teter,* to suck. The compound Maori words *mote* (*mo-te*) and *ngote* (*ngo-te*), to suck, are proofs that the word *tete* is not of modern introduction.

The English word "milk," Swedish *mjolk,* Gothic *miluc*s, is from a Teutonic base *melki,* meaning "to stroke out milk" (Skeat)—the Sanscrit *mrij,* to rub, &c. In Polynesian we have the word as—Samoan, *mili,* to rub; Maori, *miri,* to rub, to touch in passing; Tahitian, *mirimiri,* to handle; Hawaiian, *mili,* to handle, to bear or carry (here touching the sense of *vah* and *vacca*); Tongan, *mili,* to rub. The European forms are probably connected with English "smear," from √ SMA, to rub; Danish *smere,* to smear, oil, butter—as Maori *miri-miri,* to smear.

Fuel.—We know from the evidence of many travellers that among pastoral peoples the dried dung of cattle forms their principal (often their only) fuel. The Maori words *kauruki* (*kau-ruki*), smoke; *kaurukiruki,* smoky, dusky, would imply that this word was coined from some such use. The Dutch *rook,* German *rauch,* Swedish *rök,* Icelandic *reykr,* Scottish *reek,* all mean "smoke"—on a Teutonic base, *ruk,* to smoke, reek. This root is referred by Skeat to an Aryan base RUG, allied to √ RAG, to dye, colour; whence Sanscrit *raja, rajas,* dimness, sky, dust, pollen; *rajani,* night; and Icelandic *rökr,* twilight. If Skeat is right, the original sense of *reek* is "that which dims, mist." Jamieson ("Scottish Dict.") also gives *rouk* as mist, *rouky* misty. This is fully supported by Polynesian. We have in Maori *kau-nehunehu,* dusky, where *nehu* = dust, and *nehutai* spray; *koruki* (*ko-ruki*) is "cloudy, overcast:" Samoan, *fa'alolo'i* (*whaka-roroki*), to be dark and lowering (of

* Cf. Tethys, the goddess, "the nursing mother of all things." (?) See Æschyl., "Eumen.," 4, 5; "Il.," xiv., 201.

† In Hawaiian *kiki* (in Maori letters *titi*) means masturbation, precisely as *u* does. The word *te* (the *te* of *whaka-te*) means to thrust, to crowd about a person, &c.—probably a herd-word, like *po-po,* to throng.

the sky): Tahitian *rui* (*ruki*), night, to be dark or blind: Paumotu, *ruki*, night: Tongan, *roki*, dark. The Maori *korukuruku* is "cloudy;" *rikoriko* (or, as an Englishman would write it, *reeko-reeko*) is "dusky, darkish;" the Tongan form *liko-liko*, "besmeared with dirt." Scottish (Jamieson) gives *cow* and *kow* as "fuel used for a temporary fire:" Cornish, *gau*, dung (a mutation of *cau*): Irish, *caorach*, a dry clod used for fuel; *caorachd*, cattle; *boran* and *buacar*, cow-dung. Wright ("Provincial Dict.") has *cow-blakes*, "dry cow-dung used for fuel;" also *dye*, "cow-dung collected for fuel," this being the Polynesian *tae*, dung, ordure.*

I will now proceed to consider the last important form of the cattle-word in Polynesia, the word *tau*. I have already in a former paper† drawn attention to this word as used in several peculiar ways, as in writing, tattooing (*ta-tau*), tying, &c. The ancient Persians, who were "Aryans of the Aryans" (their own proud title), wrote all their literature upon prepared cowskins.‡ This may have been the connection between writing and cattle (English *taw*, to prepare skins to make them into leather). On the other hand, the most primitive bond of all may have been the use of the tau as a cattle-mark.§

The word was so general as to be equally shared by Aryan and Semitic peoples—Greek ταῦρος, Latin *taurus*, Russian *tur*, Welsh *tarw*, Gaelic *tarbh*, Irish *tor*, Icelandic *stjorr*, English *steer*, Sanscrit *sthaura*, &c., Chaldean *tora*, Ethiopian *tore*, Arabic *thawr*, Hebrew *shor*. Probably the one class of language has adopted the word from the other in ages unthinkably remote. Whether the Polynesian *tau* form has lost its final *r*, or whether the others have added it I do not know, but there is one signification at least in which the *r* sound is found in the Islands—viz., Maori *tau*, a rope (German *tau*, a rope; Icelandic *taumr*, a rein; English *tow*, &c.), where *taura* also means "rope." But the Tahitian *taura* means "a herd." And, while this coincidence fixes the derivation, we find that in all Polynesian dialects except Maori|| a second signi-

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* Samoan *tae*, excrement, to gather up rubbish; Tongan *tae*, excrement; Maori *tutae*, ordure, &c.

† "Ancient Alphabets in Polynesia," "Trans. N.Z. Inst.," vol. xx., p. 358.

‡ See Haug, "Sacred Language, Writings, and Religion of the Parsis," p. 136.

§ Taylor ("The Alphabet") says that "tau, the last of the letters, is the 'sign' or 'cross' used for marking the ownership of beasts" (32). Ezekiel, ix., 4). Bishop Andrews says, "This reward (Ezekiel, ix., 4) is for those whose foreheads are marked with tau" ("Sermons," Luke, xvii., 32).

|| The Maori form here is probably *Tauira*, a certain mythological personage, &c., for whom see "Ancient Alphabets in Polynesia," p. 368, "Trans. N.Z. Inst.," vol. xx.

fication connects it with *vaka* or *waka*. We have seen how *vaka* means not only a canoe, but a medium of the gods, a priest of a deity; so we get also a secondary meaning for *taura:* Samoan, *taula*, the priest of a deity; Hawaiian, *kaula* (*taula*), a prophet; Tongan, *taula*, a priest (*tau*, to address in prayer); Marquesan, *taua* (*taura*), a priest; Mangarewan, *taura*, a priest. The persistent Hawaiian change of *t* to *k*, common in Polynesia (even in Maori words between themselves, as *whaki* = *whati*, &c.), gives perhaps the key to the whole matter—that is to say, *tau* is *kau* (cow), and *taura* is *kaura*. Thus, Maori *tau*, "to float," approaches in meaning *kau*, "to swim;" *taupua*, "to float," compares with *poranga* (*po-ranga*), "to float," and *porena* (*po-rena*), "to float, as oil." (*Bo* = cattle-words.) Marquesan *tau* means both "to carry on the back" and to "arrive by sea."* With the bearing or carrying words we have the same interchangeable sense, the Hawaiian *kauo* and *kauwo*, "to draw, drag along," meaning also "a special blessing or favour" (as *vaka* and *taura* meant priestly interceders). Maori *tautau*, an ear-ornament, = *kai*, an ear-ornament (cf. Sanscrit *gotra* (lit. "possessor of cows"), = jewels, treasures). *Tau* means, in Maori, the ridge of a hill; *taukaka*, spur of a hill; *taumata*, brow of a hill. The northern boundary of the lands of Arya was the Taurus range, and the word *tau* has been kept in the Caucasus, &c., as the name of a hill, or range of hills, to the present day; the names of hills are Mala Tau, Mishirge Tau, &c. "Tau—like Tauern, in the Tyrol—is applied more often to a range than to any individual top." † The Polynesian chief variant seems to be *tara*, this being used, in a secondary sense, particularly for "horn." ‡ Perhaps the most general application of the word "horn" in ancient times was as a symbol (1) of lunar deities, (2) of male or regal power. Isis with the cow's head; Artemis Taurica; § the horned Hera; Ishtar (Ashtaroth), called in the Septuagint (Tobit, i., 5) "the she-Baal, the cow," &c., are instances of lunar deities. *Tara* means, in Maori, a point, spear-point; rays, to throw out rays; courage, mettle. ‖ The bull (symbol-

* What is the derivation of Maori *taupo*, "a loadstone"? Can it be possible that the magnetic needle was known in those far-back days of the Polynesian migration! Was the arrow of Abaris, by which he guided himself whither he wished to go, a *tir* (or *tau*) arrow?

† Mr. Freshfield's "Suanetia," "Trans. Royal Geog. Soc.," June, 1888, p. 349.

‡ In Lithuanian *taure* signifies a drinking-horn, as the Irish *bubhal*, horn, is connected with Latin *bubalus*.

§ Diana was not so named from the Taurican Chersonese. She was "*bicornis regina siderum.*" (Horat., "Carmen Sæc.," 35.)

‖ Also *membrum virile*.

ized by the horns) is universally typical of cosmical, regal, or national power, and also of masculine force.*

The Aramean *tur*, a "height" (*tau*), meant also "bull" and "prince." I will requote Mr. Colenso's translation of *tara o te marama* as "cusps of the moon"—the moon's horns. The Tahitian and Mangarevan vocabularies both give *tara* as "horn." "Spear-point" is a more common word, of course, with modern Polynesians, but the connection is clear: in the words of Macrobius, "Under the name of arrows, the darting of the rays is shown."† The English word "star" has been derived from a root *star*, to strew, spread; the Sanscrit *taras* (star) being supposed to have lost an initial *s*. But the Maori *tara*, to throw out rays, to emit light, would seem to have been nearer the simple notion of primitive men than any other: if so, the excrescent *s* was very early introduced. The Icelandic *tarra*, to spread out, has not the prefixed *s*. The Maori *putara* (*pu-tara*; *pu*=to blow) means "a trumpet, a shell used like a horn for signals" (Williams's Dict.).

A curious fact in connection with *tara* is that this word is used as denoting "a fable" (*korero tara*). Perhaps the stories of the elders respecting the *taura* or *tara*—impossible creatures, as the new generations of islanders began to believe—made all fabulous narratives be called *tara*. Samoan, *tala*, a tale, narrative; Hawaiian, *tala*, to proclaim; Tongan, *tala*, to tell. (Cf. Icelandic *tala*, to talk.) These, again, compare with the curious meaning of *kau* in Maori, as "*non est*"—as, *kahore-kau*, not at all; *rakau-kau*, not having trees (*rakau* = tree): Mangarevan *kakautara*, babel, confusion; and the Tahitian *aai* (*ka-kai*), a tale or fable (our old friend *kai* or *kye*, cows). This *tara*, an idle tale, in its Samoan compound, *tala-gafa*, "to recite a pedigree," also compares with Maori *kau-whau* (*kau-whau*), to recite old legends or genealogies—perhaps legends of *Kau* or *Tara*.

The English etymology of "tale" gives "a number, reckoning, narrative;" Dutch, *taal*, language, tongue, speech: both from Teutonic *tala*, a tale, number. In Maori, *tau* (*ta-tau*) means to count; so that *tau* and *tara* would be forms of √ *taur*, and the original idea "mustering" or counting cattle. The Sanscrit *tara*, "a spell for banishing demons" (Benfey), = Maori *tara*, to influence by charms. The Maori *pu-tatara* (or *putara*, also *putetere*), "a trumpet," compares with Old Dutch *tateren*, to sound with a shrill noise, to taratantara with a trumpet (Hexham); Low German *tateln*, to tattle. Cf. Maori *tutara*, small-talk, gossip, chatter.

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* Cf. Irish *tar*, I dare; Gothic *dars*, I dare; Welsh *tor*, shock, impulse (*tarw*, bull); Icelandic *thoran*, courage; Hindi *dhor*, cattle.

† Sat. i., 17.

Maori *tara* shows its *tau* derivation also in the floating sense: *Tau*, to float, = Sanscrit *tara*, crossing over, a ferry-boat; *tarana*, a raft, boat; *tarad*, a raft, float, &c.

I wrote in the first part of this paper that not only did the cattle provide for the material wants of primitive pastoral communities, but also gave them their deities. I have to show another curious interchange here of the words *po* and *kau* (cattle-words) with names of Maori supernatural beings of the lower class. The great deities of Polynesia, *Tu*, *Tane*, *Tangaroa*, *Rongo*, &c., grew to heights as great above the petty crowd of minor divinities as did Zeus, Indra, Ishtar, and Apis above their half-forgotten forerunners. In New Zealand there existed a belief in a class of malicious demons called *kahukahu*. The word is sometimes applied to a ghost or spirit of a dead person; but properly it was used only for the spirit of a child dying unborn. They were regarded as "germs" of human beings, which had untimely perished. Thus it was that a certain garment of females was called *kahukahu*, and why the walls of a house were *tapu*. ("*Ko te kahukahu piri-tara-whare.*")* This was perhaps the reason why the *kahukahu* were called "house-dwelling spirits" (*atua-noho-whare*)—on account of the tabooed walls of a dwelling. (Cf. Fijian *kau-tabu*, the wall-plates of a house.) In both Ireland and Scotland the Tarans were supposed to be the wandering evil spirits of unbaptized children. But the peculiar origin of the Maori demon leaves no doubt as to the meaning. To the Aryan the cow was a sacred symbol, the emblem of maternity and of femininity: the Sanscrit *matar*, "mother," is also "cow." Their Brahmin descendant has always held the "killer of the cow" in greater horror than we could feel for any possible sacrilege. It was the connection of this idea of femininity with the name of the cow-symbol of maternity which caused the *panniculus* to be called *kahukahu*. That at such a period women were looked upon in old times as unclean, so that even their glance defiled, we have much evidence in ancient writings, and this would account for these supposed germs of humanity being looked upon as evil spirits. A synonym for these demons is *Atua-poke* (unclean deities). When I assert that these spirits, *kahukahu*, are the

* Verbi *kahukahu* significatio simplex est panniculus: et panniculus quo utitur femina menstrualis nomine *kahukahu* dicitur κατ' ἐξοχήν. Apud populum Novæ Zelandæ creditur sanguinem utero sub tempus menstruale effusum continere germina hominis; et secundùm præcepta veteris superstitionis panniculus sanguine menstruali imbutus habebatur sacer (*tapu*), haud aliter quàm si formam humanam accepisset: mulierum autem mos est hos panniculos intra juncos parietum abdere: et hâc de causâ paries est domûs pars adeo sacra ut nemo illi innixus sedere audeat. (See Shortland's "Maori Religion," p. 107.)

"bogeys" of our childhood I shall doubtless cause a smile to appear on the faces of my readers; but the facts are very stubborn. In Maori, *poke* (*boke*) means "to appear as a spirit" (Williams's Dict.), and is, I believe, associated with *po*, either as the abode of souls or as the Cosmic Cow. While engaged in gathering information as to the word *popoa*, "food eaten for the dead," I learnt much concerning these *poke* spirits. Several classes of spirits are *poke*, but especially the malignant *kahukahu*; but, whereas the latter is essentially unclean, the spirit of a dead man only becomes *poke* if the rites of the funeral offering are neglected,* their *manes* not being of themselves able to kill or injure living persons, but only to incite the *atuas* (demons) to do so: the spirit of the adult, if neglected or revengeful, could only plant the germs for the other *poke* spirits to nourish. This was the reason why (as amongst the Aryans) it was a great misfortune to a chief to be without legitimate offspring, and not to have a child to make the death-offering.† Hence come the proverbs "*Kakore he uri, he tangi*"—"Without offspring, wailing"—and "*Ka ora koe, ka pihea*"—"You will live (be immortal), having the death-song chanted."‡

If, then, the Maori *poke* means unclean, evil spirit, to appear as a spirit, we shall find connected with it the Samoan *po'e* (*poke*), "to be afraid," and in this sense a host of words in the Indo-European languages for "spirit" and "fear." The English word *boggle*—to start aside, swerve from fear—is

* For description of the offerings of cakes, &c., made for the dead in ancient India and Persia, see Tylor's "Primitive Culture," ii., 30, 30; Ward's "Hindoos," vol. ii., 332. For the Roman festival in honour of the dead (*Feralia*) see Lempriere, "Clas. Dict."

† "Parva petunt manes. Pietas pro divite grata est
Munere. Non avidos Styx habet ima deos."
—Ovid, Fast. ii., 533.

‡ Mr. Locke, R.M., of Napier, a Maori scholar and "initiate" of priestcraft, informed me that the sacred food for the dead—*popoa*—was the bread made from the pollen of the bulrush (*Typha angustifolia*). Those who wish to know more concerning this bread (called *pua* when "common") will do well to read the Rev. R. Taylor's ("Te Ika-a-Maui") account of it. He states that Scinde (India) is the only other place where the bread made from bulrush-pollen is eaten. It is in Scinde called "*boor*," according to Professor Lindley. "*Boor*" is evidently the New Zealand *pua* (*anglice poo-ah*), with the broadened *ah* into *ar*, of which I before spoke. Captain Wood, in "Journey to the Source of the Oxus" (61), tells us, "It is the solitary bulrush-gatherer, who, with only his *mussuk* (inflated-hide float) for support, braves all the dangers of the stream to procure the root of the bulrush as food for himself and his little ones." For evidence as to Maoris eating root of bulrush, see Colenso, "Trans. N.Z. Inst.," vol. i., 348. The bulrush plant is called in New Zealand *raupo* (*rau-po*), where *rau* = "leaf." What does *po* mean here? Bull? As the etymology of "bulrush" is unknown, the word may be older than has been thought.

connected with *bogle*, a spectre; Welsh *bwg*, a goblin; our *bug* and *bugbear*, a spectre; and is the Irish *puka*, an elf, the "Puck" of Shakespeare.* *Bugaboo*, with its cattle termination (*bu* or *bw*), evidently belongs to pastoral demons. Welsh, *bw*, threat, terror, bugbear; *bw-bachu*, to scare; *buw*, a cow; *bwla*, a bull; *bwci*, a hobgoblin; *pwca*, fiend; *pwci*, goblin: Spanish, *bu*, a word used to frighten children: German, *böse*, evil, devil: Danish, *pokker*, devil (in English, Piers Plowman and Matthews's Bible give *pouk* for devil): Gaelic, *bodachs*, an evil spirit: Manx, *boa*, a cow, fear, affright; *boag*, a bogey; *boo*, fear: Scottish, *bo* (also *bu* and *boo*), a word of terror, connected by Jamieson ("Scot. Dict.") with Teutonic *bauw*, larva, spectrum; also *puke*, an evil spirit. Grimm, in his "Teutonic Mythology," gives very many words on this form—*popel*, *pobelmann*, *popanz*, &c.—as ghosts for frightening children, and belonging to the class of spirits called bull-man, buller-man, *poltergeist*, &c. Icelandic, *bola*, to bully; *boli*, bull. In obsolete provincial English† we have *bo*, hobgoblin; *bogge*, bugbear; *boll*, a ghost; *bole*, a bull; *boman*, a hobgoblin. The word seems everywhere. The tutelary deities of the Battahs of Sumatra are called *Bogus*, and are the souls of the dead. The Motu, a Polynesian-speaking people among the blacks of New Guinea, call a fool *bobo*, as do the Spanish; but *boloa* is "possession by an evil spirit." The Malays of the Peninsula have an evil spirit called *Polong*, an elfin creature which feeds on the blood of its possessor. In Puck-hairy we have a sprite named after these animal deities. Hairiness is one of their attributes. Thus the Vulgate has "*et pilosi saltabunt ibi*" (Isaiah, xiii., 21), where the LXX. has δαιμόνια. These *bo* words receive strongest confirmation as to their ultimate signification when we compare them with the "cow" words. Scottish *cow* or *kow*, a hobgoblin, to depress with fear. This is also the English sense "to cow," "to cower." Icelandic, *kuga*, to cow, tyrannous (*kusa*, a cow). Scottish, *cow-man*, a name for the devil (just as "bull-man" and "bull-beggar"); *cowin*, an alarm, a fright; *wirry-cow*, a goblin, the devil; *cow-carl*, a bugbear; *water-cow*, a spirit of the waters. I think that these words show that our "bogeys" had a cattle origin, and that the Maori *poke* (*pouke*, *puck*, &c.) and *kahukahu* (*kow* of Scottish) have probably the same source.

In conclusion, I will point out that the curious series of "coincidences" is completed by the words for "herd." I have considered that *kahu* (Rarotongan *kau*) is the same word

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* Keightley, in his "Fairy Mythology," says that "*pixy*" is "*pucksy*;" *pooka* or *phooka*, a spectre, a dark-looking thing like a colt.

† Wright's "Provincial Dict."

as *kau*, because the meanings of *kau*, *kahu*, *tau*, *tahu*, *ngau*, *ngahu*, constantly cross and interchange in Polynesia, as chewing, floating, clothing, &c. *Kahui* is a "herd" in Maori, as *taura* is "herd" in Tahitian.* We have already seen that *kau* meant a troop of persons, a fleet of canoes, &c. (Cf. Lithuanian *gauja*, a herd = Sanscrit *gavya*, a herd of cattle.) There is a Polynesian word *mu* (*Anglice*, *moo*) which seems to be a "herd" word, and there is nothing ridiculous in the idea that a word springing from the idea of lowing cattle should have many derivatives. In Maori *mumu* means a gentle sound, a "murmur" (another instance of added *r*). The English *murmur* comes through French from Latin *murmur*. Icelandic, *murra*; German, *murren*, to murmur. The English *mumble*, *mummer*, &c., are formed in the same way; but we are told by Skeat that the sound *mum* is "used by nurses to frighten children, like the English *bo*." We find from another author that "*bo* is essentially a Tauric word."† And the German *mummel*, a bugbear, compares with an infinite number of others indicating "fear" and "cattle." The Greek *βοέη* an ox-hide, *βοάω* to roar, bawl, stands side by side with the primitive *μυκάομαι* (*mukaomai*), to low, bellow; *μυκητικός*, bellowing (perhaps *μυρίος*, countless); *μύζω*, to murmur (*μυμῦ*).‡ Portuguese, *mugido*, lowing: Latin, *mugire*, to bellow: Scottish, *moo*, the act of lowing; *moolat*, to murmur. The Gond *mura* = cow; and in Silong (Archipelago), while *k'bau* is buffalo (Malay, *karbau*), the cow is called *l'mu*. On the Polynesian side, beside the Maori words *mumu*, murmur, and *mui*, to swarm, we have—Tahitian, *mumu*, to make a confused noise; *mutamuta*, to *mutter* (another coincidence?); *omumu*, to whisper: Hawaian, *mumu*, to hum; *mumuhu*, to sound as many voices; *mumulu*, to come together in a crowd: Tongan, *mumu*, to collect together; *mumuhu*, the sound of sea or wind: Mangarevan, *mumu*, an idiot, a fool; as the Spanish and Motu have *bobo*, fool: Samoan, *mu*, to murmur; *mumu*, to go in swarms: Fijian, *mumu*, to go in troops. I think it can hardly be doubted that these words signify not only "murmur," but the murmuring arising from crowds or herds coming together, as Maori *popo* means to crowd, throng.

If I should be asked to what conclusion I had come as to the genesis of these words, I should reply that it appears from the evidence that there was probably a root AK, which sometimes became *ka* or *aka*. This *ak* acquired in one direction a (digamma) prefix *v* or *b*, and became *vak*; in another

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* *Kahui* may be a compound of *hui*, to assemble; but, on the other hand, *hui* is probably an abraded form of *kahui*.

† "Phallicism," Hargrave Jennings, p. 209.

‡ As to "murmur" and "multitude," see Canon Farrar's "Language and Languages," p. 140.

direction *ka* became *nga*, *ngau*, and *kau*. The *ak*, *ok*, *uks*, *ox*, *vaks*, *vach*, &c., became associated mainly with the idea of "carrying," whilst *ngau* and *kau* (gnaw and cow) remained connected with "ruminating" and "milking." It is an exceedingly difficult thing to say which of two primitive ideas is the archaic one, when we have such a vast distance of time through which to reach. The Sanscrit *açva*, horse (*açva* = *equa*), is supposed to have had its radical meaning in "swift;" but if the root *aç* means "*permeare, penetrare*" (according to Pictet), it may have had its first origin in *ak*, from "dashing, butting" (Maori, *aki*, to dash; *a*, to drive: Sanscrit, *aj*, to drive: Latin, *ago*: Samoan, *aga*, to act, to go: Icelandic, *aka* (*ok*, *oku*, *ekit*), to drive, transport). "Swift" would be a secondary attribute, attaching itself to the horse, and produced by the horse, after he had received his *ak* ("bearing") name. Skeat considers "acre" as probably either pasturage or hunting-ground ($\sqrt{}$*ag*, to drive; or *ak*, to pierce). I would make one suggestion in regard to this common origin of horse and ox name, and that is that thé word was at first applied to neither, but to another animal partaking of the nature both of ox and horse. I mean the *yak* of the Pamir ancient cradle-land. In the "Journey to the Source of the Oxus" (p. 208 *et seq.*) there is a notice of "a yak, or *kash-gow*, as the animal is here called, standing before a door with its bridle in the hand of a Kirghiz boy. . . . It stood about 3ft. 6in. high, and was very hairy and powerful. Its belly reached within 6in. of the ground, which was swept by its bushy tail. The long hair streamed down from its dewlap and forelegs, giving it, but for the horns, the appearance of a huge Newfoundland dog. It bore a light saddle with horn stirrups, and a cord let through the cartilage of the nose served for a bridle. . . . The yak is to the inhabitant of Pamir and Thibet what the reindeer is to the Laplander in northern Europe. . . . He frequents the mountain slopes and their level summits. Wherever the mercury does not rise above zero, there is a climate for the yak. The heat of summer sends the animal to what is termed the old ice—that is, to the regions of eternal snow—the calf being retained below as a pledge for the mother's returning, in which she never fails. In the summer the women, like the pastoral inhabitants of the Alps, encamp in the higher valleys which are interspersed among the snowy mountains, and devote their whole time to the dairy. The men remain on the plain and attend to the agricultural part of the establishment, but occasionally visit the upper stations; and all speak in rapture of these summer wanderings. The kash-gows are gregarious, and set the wolves which here abound at defiance. Their hair is clipped once a year, in the

spring. The tail is the well-known chowry of Hindostan; but in this country its strong, wiry, and pliant hair is made into ropes, which for strength do not yield to those manufactured from hemp. The hair of the body is woven into mats, and also into a strong fabric which makes excellent riding-trousers. The milk of the yak is richer than that of the common cow, though the quantity it yields is less." There is no part of the world "where there are such numbers of wild animals as may be met on the slopes of northern Thibet. Here, in one day, the traveller may see hundreds of herds of yaks, wild asses, and antelopes, and these show no signs of alarm at the approach of man. Their numbers may be estimated not by tens or hundreds of thousands, but by millions."* This animal, then, milk-bearing, load-carrying, garment-supplying, assembling in droves, with horns of ox and tail of horse, loving the cold and ice, may have been the true *primal* domestic animal of that land of the early Aryans where there were "two months of summer and ten of winter." The word *aleph*, the Semitic word for "ox," was certainly anciently applied to this animal. Schrader† says of the obelisk of Salmanassar that the word "ox" refers to the *jak-ox* represented on the corresponding relief.

* Prejevalesky's "Journeys and Discoveries in Central Asia," "Trans. Roy. Geographical Soc.," April, 1887, 229.

† "Cuneiform Inscriptions," vol. i., 177.

NEW ZEALAND INSTITUTE.

NEW ZEALAND INSTITUTE.

TWENTIETH ANNUAL REPORT, 1887-88.

THE Board held meetings on the 30th August and 30th September, 1887, and on the 13th February, 23rd March, and 9th May, 1888.

The following members retired from the Board in conformity with clause 6 of the New Zealand Institute Act: namely, Mr. W. T. L. Travers, Mr. Thomas Mason, and the Ven. Archdeacon Stock. These gentlemen were all reappointed by His Excellency the Governor.

The members elected as Governors of the Board by the incorporated societies are—Mr. J. McKerrow, F.R.A.S.; Mr. T. Kirk, F.L.S.; and Dr. Hutchinson.

There having occurred three vacancies in the list of honorary members of the Institute, the following elections took place: Professor McCoy, Baron C. von Ettingshausen, and Professor van Beneden.

The following are the members now belonging to the Institute:—

Honorary members	30
Ordinary members—	
Auckland Institute	254
Hawke's Bay Philosophical Institute ...	121
Wellington Philosophical Society ...	253
Philosophical Institute of Canterbury ...	117
Nelson Philosophical Society... ...	36
Westland Institute	78
Otago Institute	137
Southland Institute..	72
Making a total of ...	1,098

The volumes of "Transactions" now in stock are—Vol. I. (second edition), 280; Vol. V., 35; Vol. VI., 30; Vol. VII., 130; Vol. IX., 130; Vol. X., 165; Vol. XI., 50; Vol. XII., 55; Vol. XIII., 55; Vol. XIV., 80; Vol. XV., 190; Vol. XVI., 200; Vol. XVII., 230; Vol. XVIII., 170; Vol. XIX., 200; Vol. XX., not yet fully distributed.

The Volume XX. was published in June last, and contains 52 articles; also addresses and abstracts of articles which appear in the Proceedings. The volume contains 528 pages of letterpress and 22 plates.

The following is a comparison of the contents with that of the previous year's volume:—

	1888. Pages.	1887. Pages.
Miscellaneous	80	120
Zoology	140	212
Botany...	116	114
Geology	96	134
Proceedings	47	48
Appendix	49	52
	528	680

The cost of printing Vol. XIX. (new series) was £535 15s. 5d. for 680 pages, and the cost of the present volume—XX.—is £415 10s. for 528 pages.

The Honorary Treasurer's statement of accounts is appended, from which it will be observed that there is a credit balance of £130 4s. 9d., besides the sum of about £50 in the hands of the London Agent.

W. B. D. Mantell,
Acting Manager.

Approved by the Board.
G. M. Waterhouse,
Chairman.

23rd July, 1888.

New Zealand Institute Accounts, 1887–88.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Balance in hand on 29th August, 1887 ..	36	10	9	For printing Vol. XX. of "Transactions" ..	415	10	0
Vote for 1887–88 ..	500	0	0	Miscellaneous items, purchase of books, &c.	16	17	6
Contribution from Wellington Philosophical Society, one-sixth annual revenue ..	26	1	6	Balance in hand ..	130	4	9
	£562	12	3		£562	12	3

23rd July, 1888.

G. M. Waterhouse,
Honorary Treasurer.

PROCEEDINGS.

WELLINGTON PHILOSOPHICAL SOCIETY.

FIRST MEETING: *13th June, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

New Members.—T. D. McDougal, W. B. Hudson, and A. Boardman.

Inaugural address by the President, W. M. Maskell, F.R.M.S.

ABSTRACT.

The PRESIDENT, after thanking the Society for the honour done to him by his election, proceeded to deliver the annual address. He began by congratulating the members of the New Zealand Institute upon the appearance of the twentieth volume of "Transactions," and therefore upon the completion of twenty years of good and solid work for the benefit of the colony—work undertaken without any view to emolument or reward, and solely with the intention of disseminating useful information. At the same time he recognised that there was some foundation for the complaint often made that the "Transactions" contained almost too much of the purely natural and physical sciences. This may have been inevitable in the past; but perhaps the time may have arrived when an extension of work might be brought about, and he hoped to be able to suggest some plan during the year for encouraging young men to take up other lines of study, and to publish their results. Little or no assistance could be hoped for from the Colonial Legislature, which was now cutting everything down to the lowest limit, and which evinced no disposition to liberality towards learning. The vexatious restrictions to which respectable citizens were subjected if they desired to make good use of the library which the colony had given to Parliament, were an evidence that the Legislature could not be in the least relied upon to help the Institute, even though it was demonstrable that the "Transactions" were capable of being directly profitable from an educational point of view. Still, perhaps a good deal of difficulty undoubtedly arose from the character of the young men of New Zealand, who certainly did not seem to show much inclination to intellectual pursuits. Athletics and, perhaps, practical business seemed to absorb their entire attention; and if some addicted themselves at all to study this was probably in the great majority of cases only with an eye to the positions and the salaries to be gained by it. *Finis scientiæ opes:* the test of knowledge is the money to be made from it. Such seemed to be the philosophy of young New Zealand.

Passing to the scientific portion of his address, the President drew attention chiefly to the branch of study which he had himself followed—microscopical investigation. He began with the seeming paradox that, whilst the microscope since its invention has taught us very much, it had also taught us very little. In the improvement of mechanical appliances and adaptations the advance of the microscope had been most wonderful, and an illustration of this was afforded by the comparison of a microscope by a modern maker, exhibited on the table, with the model of a microscope

made and used by A. Leeuwenhoek, one of the most celebrated of the early discoverers, about the year A.D. 1700. This model, which would be placed in the Colonial Museum, showed that the original instrument was of extreme roughness, having only a single lens fixed in a metal plate, to which a small apparatus was attached at the back for holding an object. The improved mechanism of the modern microscope was indeed wonderful, and probably left little more to be effected. Still, this was but a question of degree and of mechanical skill: as regards the deductions from the teaching of the microscope, we are no further advanced now than the observers of Leeuwenhoek's time.

The two great problems, What is life? and How have the variations of organic beings been brought about? are not solved by the microscope—which, indeed, in revealing to us innumerable wonders of fact, has not lent itself to the advancement of modern scientific theory. The prevalent tendency of modern thought is in the direction of discovering a physical, a material basis of life; and all the energies of many accepted leaders nowadays are bent towards this end. But they receive no aid from the microscope, which, as it every day leads them further on in the domain of facts, only does so to show still the same impassable gulfs preventing the desired solution of the problem. And as regards the second question—of the variations of organisms—the microscope seems to provide even a positive bar against modern theories. For these rest fundamentally on a few assumptions, one of which is that in organic nature simplicity of construction implies inferiority, and therefore priority: the simplest organisms are taken as necessarily inferior, and therefore precedent, to the more complex. An instance of the fallacy of this assumption is afforded by the microscopic animal, hydra (common about Wellington and elsewhere), an animal of almost the last degree of simplicity, and on that account placed in modern systems in a very "low" order of beings. It could be shown that the marvellous properties and powers of the hydra formed a direct contradiction to the fundamental assumption above mentioned of the evolutionary theory. On the whole, the microscope, whilst it has taught us, and will continue to teach us, ever more and more in the domain of fact, has in the domain of speculation left us no further advanced than the early observers two centuries ago—even no further advanced than the philosophers of ancient Greece.

The President exhibited under the microscope a specimen of the hydra.

Papers.—1. "On a New Species of Kiwi (*Apteryx bulleri*)," by R. Bowdler Sharp, F.L.S., F.Z.S., Honorary Member N.Z. Institute (Ornithological Department, British Museum); communicated by Sir Walter Buller. (*Transactions*, p. 224.)

2. "On the Varieties of a Common Moth (*Declana floccosa*)," by G. V. Hudson. (*Transactions*, p. 190.)

Second Meeting: *27th June, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

Papers.—1. "On Rabbit-disease in the Wairarapa," by Coleman Phillips. (*Transactions*, p. 429.)

Mr. John F. McClean, M.R.C.V.S., by permission of the meeting, said that he objected to the wholesale introduction of "rabbit-fluke" as a means of eradicating the pest, on the ground of its being the same

hydatid that caused the disease "sturdy" or "gid" in sheep, and quoted Dr. Cobbold to that effect. That the disease "sturdy" in sheep did prevail in the Wairarapa he was convinced, from inquiries he had made among sheep-owners in that district; though in nearly all cases, from a want of knowledge of the subject, it had not been identified as "sturdy," but mistaken for "ergot"-poisoning. As a matter of fact, ergot, he said, had little or no action on sheep except during the period of gestation; but in healthy ruminants, when obtained or administered continuously for a considerable period, it would most likely cause sloughing of the hoofs; this, with the exception of general falling-off in condition, being usually the first observable symptom of ergot-poisoning. All the symptoms that had been described to him as due to ergot-poisoning were, as a matter of fact, identical with the symptoms of "sturdy." Again, as a rabbit-destructor, how did the disease act? In the rabbit we find the hydatid lodged in the connective tissue of the skin and muscles; it grows to the size, perhaps, of an orange, and is said to displace the vital organs to such an extent as to cause death. But this is a very slow process: it takes weeks for the hydatid to grow to even an appreciable size, and does not during this period interfere with the reproductive powers of the rabbit; and when it *has* grown to a size sufficiently large to cause the displacement of a vital organ, *this* is not sufficient to cause death. We all know how even men can and do live with their vital organs in all sorts of strange positions, and bunny does not seem less able to do so; in fact, this displacement in the rabbit being so very gradual gives nature a chance of accommodating itself to its altered circumstances. He said he would be inclined to attribute the improvement in the rabbit-pest in the Wairarapa to the shooting, poisoning, and turning-out of the rabbit's natural enemies, which Mr. Coleman Phillips said had taken place, though he would certainly grant that rabbit-fluke, existing as widely as Mr. Phillips had represented it, would necessarily cause a certain mortality; but he believed this mortality would be extremely small, considering the nature of the pest we have to deal with, and urged that the disease had been propagated at far too great a risk to the sheep in the district.

Mr. Coleman Phillips, in reply to Mr. McClean, remarked that he did not believe at all that the bladder-worm of the rabbit gave the sheep in the Wairarapa sturdy, or gid. There were not many cases of sturdy, or gid, in the colony. It was a rare complaint amongst sheep, but in the Wairarapa a few sheep had become apparently sturdied from eating ergot. Mr. McClean said the runholders were wrong in thinking that ergot was the cause of this; but Mr. Phillips thought that the runholders were right. He, however, desired to thank Mr. McClean for calling attention to the matter, as he was equally desirous of and interested in keeping diseases away from sheep. Professor Thomas had quoted from Rose in his report, and that gentleman drew from that authority a conclusion quite different from that of Mr. McClean. Bladdery rabbits were not harmful to sheep; and as to human beings, the Norfolk warreners have been in the habit for years past of pricking the bladders, and then sending the rabbits to market in the ordinary way. There were very few cases of hydatid heard of in England, where bladdery rabbits must often be eaten.

3. "Two Suggestions for the Consideration of the Governors of the New Zealand Institute," by A. de B. Brandon.

Abstract.

The writer, in calling attention to the many ways in which the measurements of small objects were recorded, stated that fractions (both vulgar and decimal) of an inch, lines, millimetres, and micro-millimetres were used by different writers, and suggested that the Governors of the Institute, in order to lessen the labours of a student, should insist on the adoption of one system of measurement in papers submitted for publica-

tion in the "Transactions." The writer also pointed out the incongruity sometimes caused by the use of personal surnames as the specific description of certain animals of small size, and suggested that proper names should not be used indiscriminately in the naming of new genera and species, but that good reason should be assigned for such use, and the approval of the Governors first obtained; and he further proposed that the Governors should publish a few elementary rules for the formation of the possessive case when proper names were latinised.

Mr. Hulke was glad that Mr. Brandon had brought the matter of measurement forward. It was most important that there should be a uniform system, and it ought to be that formerly introduced by the French, but now used in America and all continental States—namely, the metric system. We should teach it in our schools, to prepare for its general use fifty years hence.

Captain Hewett agreed that the decimal system should be uniformly adopted.

The President agreed entirely with the author's views on this subject. He suggested that Mr. Brandon should bring the matter before the Governors of the Institute, in the form of a definite resolution for their consideration.

The President drew attention to a valuable series of works, giving the latest information on the Hessian fly, which had been presented to the library.

Third Meeting: *25th July, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

New Member.—T. H. Robinson.

Papers.—1. "On the Limestones and other Rocks of the Rimutaka and Tararua Mountains," by A. McKay, F.G.S.

Abstract.

Mr. McKay said that several years ago Mr. J. C. Crawford endeavoured to draw attention to the existence of valuable building-stones in the immediate vicinity of Wellington; and he believed that Mr. Crawford partly opened up a quarry on his property forming the Miramar Peninsula. Attention was at the same time drawn to some rocks on the range north-west of the Botanic Gardens, which were subsequently examined by Mr. Cox, late Assistant Geologist. All of these rocks proved too hard to dress easily, and they had consequently not come into general use. In the month of October last, the speaker said, samples of a comparatively soft sandstone were brought to the Colonial Museum from the western slopes of the Tararua Mountains. Shortly afterwards he examined the rocks of the range forming the water-parting between the Ruamahanga and Manawatu basins, with special reference to the occurrence of limestone five miles south of Eketahuna, and close to the main line of road to Masterton. These limestones formed a bed 10ft. to 12ft. thick, and were sufficiently hard to take a good polish. They varied in colours, being red, green, or grey, and were usually veined with white calc-spar veins; but, unfortunately, at the outcrop, and apparently throughout, the stone was so much jointed that no blocks more than 2ft. 6in. appeared likely to be obtained. Later in the season, Mr. McKay said, he explored the eastern slopes of the Tararua Ranges between the Waingawa and Tauherenikau Valleys, and along the gorge of the Waiohine River. A great part of the high vertical walls of rock forming the Waiohine Gorge was formed of calcareous diabasic ash. The rocks appeared to be an altered volcanic ash, and would be very beautiful if cut and polished. In some parts of the Waiohine Gorge the more cal-

careous rocks of a mixed white and green colour would quarry in large blocks, and take excellent polish. They were, however, so situate that at the present time they could hardly be worked with profit. The line of calcareous rocks crossed the Tauherenikau and stretched along the Rimutaka Range to the railway-line at the foot of the steep incline on the west side of the "Summit," but he could not say how far it was traceable as a calcareous band following the range south. On the western side of the range limestones of like character occurred, and amongst the specimens on the table was one obtained from the Otaki Valley, and presented by Mr. Wallace. The distance of the outcrop was about nine miles from the railway-line. The existence of calcareous rocks in the Makara Valley had been known for some time, on Mr. Thomas Robinson's land. Further to the north-west, in the adjoining property, there was a body of rock forming a thick bed, of which about 50 per cent. is carbonate of lime. This, too, appeared to have been of volcanic or tufaceous rock. He had obtained samples, but they had proved excessively hard. If this stratum had been softer it might have proved valuable stone, as it was capable of being quarried in blocks of any size up to 7ft. in length and breadth. The stone was capable of receiving a very high polish, and the more beautiful parts of the stratum might pay for working despite the drawback of hardness. On the sea-coast, at Red Point, about a mile to the east of Sinclair Head, some very beautiful specimens of red and green slates had been obtained. The red slates were overlain by a considerable amount of grey and reddish quartzite, the bands being curiously contorted, and the quartzite was overlain by some 25ft. to 30ft. of a hard, brown, jasperoid rock, veined yellow and white, which, though very hard, was very beautiful when polished. Over this last was a mixture of serpentine, hæmatite, and granular limestone or calc-spar, which was not too hard to cut and polish; and, as the sample before the meeting would show, it was a very beautiful rock. The total thickness of these rocks, including the quartzite, was about 300ft., and they were so situate and exposed that they could be quarried with comparative freedom, and at small expense. Were the means of transit to Wellington other than over a heavy and rugged beach to the mouth of Happy Valley, Mr. McKay said that there could be little doubt but that the red and green slate might be worked and placed upon the market at once; but, however beautiful the jasper rock might be, to work it would require the use of expensive machinery.

Mr. Brandon considered the discovery of this marble most important, and he hoped it would prove a profitable industry for Wellington. It was a pity the rock was so hard; but, no doubt, with improved machinery this could be overcome. Judging from the samples on the table, if the stone could be procured at a reasonable cost, we could compete against the world in producing mantelpieces, &c.

Mr. Park would like to know if the slates were quite oxidized and anhydrous. He pointed out that if this was the case the discovery would prove of great value to Wellington, where building-stones were much wanted.

Mr. Robinson said that the specimens of marble referred to, from Makara, were obtained from the surface, where they had been long exposed to the atmosphere: the rock under the surface would probably not be so hard.

Mr. McKay, in reply, said that the rocks were composed of material completely oxidised, and that in the quarry this was shown by the absence of stains along the joints. He quoted the analysis, which showed that the rocks only contained a little more than 1 per cent. of water. He also read extracts showing that some of the marbles closely resembled the mixed characters of the *verde antico* of the Italians, and the African breccia marbles.

2. "On the Natural History of Three Species of *Micro-lepidoptera*," by G. V. Hudson. (*Transactions*, p. 189.)

3. "On the Mole-cricket in New Zealand (*Gryllotalpa vulgaris*)," by T. W. Kirk, F.R.M.S. (*Transactions*, p. 233.)

Mr. Hudson remarked that the mole-cricket had been the subject of many interesting memoirs on the anatomy of insects, and its arrival would therefore be interesting to entomologists. He did not think it was likely to do as much harm as the author thought.

Mr. Brandon said it was a pity this insect should have been introduced, and he thought information should be circulated as to the best means of getting rid of it.

The President remarked that from an entomological point of view the occurrence here of these mole-crickets was interesting. As for their hurtful propensities, opinions seemed to be divided; but it should always be remembered that comparisons between New Zealand and England were not always correct, on account of the difference of climate. He, however, took the opportunity of saying that experience in this country seemed to point to the fact that imported animals, probably both useful and noxious, unless fostered in some special way, after greatly increasing for some time, appeared to decrease. As instances of this, in connection with useful animals, might be taken the pheasants and partridges, which in some parts of the colony—for example, North Canterbury and Amuri—after growing into such numbers that they might be seen in every paddock, were now becoming rare, if not very rare. Doubtless poachers, cats, fires, rats, &c., had something to do with this; but he thought they did not account for all of it. Nor could it be said that these birds were not adapted to the country, else why had they increased so largely? In like manner, he was informed, one of our worst insect-enemies, *Icerya purchasi*, is supposed to be doing much less damage than formerly, if it is not, indeed, dying out altogether. It may be that some law obtains whereby new importations, good or bad, useful or noxious, flourish with excessive fertility for a while, and then are apt to die out. Perhaps this would be the case even with the rabbit; perhaps also these mole-crickets would come under the same law.

Mr. Park did not think there was any great danger to be apprehended from the rapid spread of the mole-cricket, which, according to Mr. Kirk's own statement, had only increased at the rate of 100 per cent. in seven years. He thought there was nothing in this to alarm farmers or gardeners.

Mr. Kirk, in reply, said that the farmers and market-gardeners had a much more lively interest in the mole-cricket than entomologists had, as they would be direct losers should the insect increase rapidly, while the scientists' interest was purely intellectual. He had not stated that the insect had only increased at the rate of 100 per cent.; he merely said that only three specimens had fallen into his hands: but he had not looked for them, and probably, now attention had been directed to the subject, we should find that many other persons had observed the creature without knowing what it was.

4. "On the Supposed Occurrence of Two Sets of Green-sand-beds at Waihao Forks, South Canterbury," by Alexander McKay, F.G.S.

Abstract.

This paper dealt chiefly with certain mistakes and misapprehensions contained in previous papers on the geology of the Waihao Valley, and explained some matters complained of in Professor Hutton's last paper on this subject. In vol. xix. of "Transactions of the New Zealand In-

stitute" Professor Hutton sought to show that the Waihao Forks greensands do not underlie the limestones of the Oamaru system at that place; and Mr. McKay, in reply, endeavoured to prove that they do. In vol. xx., "Trans. N.Z. Inst.," Professor Hutton admits there is a greensand under the limestone, but contends that it is not the greensand equivalent to that at the Waihao Forks, which, as appears, he still regards as younger than the Waihao limestone. Mr. McKay also admits the occurrence of two distinct deposits or bands of greensand, but he maintains that both have a position inferior to the Waihao limestone.

Mr. Park said there was really no geology in this paper; it was merely an explanation of some personal differences between the author and Professor Hutton. He deplored the fact that personalities should find their way into scientific discussions, and thought it would be wise to exclude such papers from publication.

5. Mr. James Wallace gave an interesting account of the recent discovery of manganese upon property near the Wellington-Manawatu Railway Company's line. He stated that a quantity had been sent home for a professional opinion as to its real value. He stated that upon analysis in the Colonial Laboratory the ores yielded, in the case of the oxide, 75 per cent., and of the carbonate, 84 per cent. of manganese.

Mr. McKay considered this an important discovery: it occurred in very large blocks, and would no doubt prove of commercial value.

Mr. Hughes, who had also visited the locality and seen the deposit, spoke highly of it. He had sent samples to England for expert opinion.

Fourth Meeting: *22nd August, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

New Member.—A. B. Keyworth.

Papers.—1. "On the Oil-bearing Strata of the North Island," by J. Park, F.G.S.

Abstract.

Mr. Park said that the oil-strata of this island belonged to two formations—one of pleistocene and the other of cretaceous age. The former included the petroleum springs at Taranaki, and the latter the oil-rocks at the east coast of Wellington and Poverty Bay. The geological conditions and the surface-evidences of oil at these places were discussed at considerable length. On the east coast of Wellington the strongest gas-spring was that at Blairlogie, the flow of gas being about equal to the discharge of an inch pipe. The oil-strata, consisting of slaty shales and crumbling marly clays, were everywhere much shattered and contorted. The gas-spring at Langdale was unlike any other in the district. The gas was sulphuretted hydrogen, and the water accompanying the gas belonged to the sulphurous or hepatic class of mineral waters, which possess valuable medicinal properties. The gas-springs at Ika, Aohanga, and Akitio were feeble compared with that at Blairlogie. Passing on to Poverty Bay, Mr. Park said that the first report on the district was made by Sir James Hector in 1873. Gas-springs were numerous throughout the whole district, and at places oil oozed from the rocks and collected on the surface of lagoons and pools. The author quoted from the reports of Sir James Hector and Mr. McKay to show the character of the oil-strata, which consist of grey contorted sandstones and dark-grey shaly marls. The strata are everywhere much disturbed and broken. At Taranaki the oil-strata consist of volcanic agglomerates and tufaceous sandstones,

containing beds of lignite. The true source of the oil is still undetermined, but is probably, as suggested by Sir James Hector in 1866, the coal-seams which are supposed to underlie Mount Egmont. Before proceeding to discuss the prospects of oil at the places just reviewed, Mr. Park briefly described the geological conditions usually attending the production of oil in other parts of the globe. Mineral oil, he said, was obtained from two sources—namely, from bituminous shales by distillation, and as a natural product from certain oil-strata. Reference was then made to the oil industry in Scotland, which continued to hold its own against the natural oils of America and Baku. Petroleum was found associated with shales (or coals) and sandstones. The former yield the oil, while the latter serve as reservoirs to collect the oil. The author then went on to consider the prospects of payable oil in the three districts already described.

Prospects on East Coast of Wellington.—He did not think the indications sufficient to warrant the assumption that payable oil would be found in this district, his reasons for this belief being as follows: (1.) That the shales contained too small a proportion of carbonaceous matter to yield oil by distillation. (2.) That the strata are too much shattered to afford the pressure necessary to condense the volatile gases.

Prospects at Poverty Bay.—The author said that, after a careful consideration of the surface-evidences, he was of the opinion that payable oil would not be found at the places where boring was at present being conducted, his reasons being the same as in the case of the east coast of Wellington. He said the Awanui shale could not be regarded as the source of the oil, as it was always at or near the surface. The dark-grey shales were no doubt the true source, but they contained only 1 or 2 per cent. of carbon, while the oil-shales of Pennsylvania contained from 10 to 20 per cent. As regards his second objection, he said the strata were too much shattered and tilted to afford the pressure to condense the volatile hydrocarbons, and to prevent leakage on the surface. Ample surface-manifestations were not considered a good indication of payable oil. He thought further explorations might discover places in the oil-belt where the geological conditions were more favourable for the accumulation of oil.

Prospects of Payable Oil in Taranaki.—With regard to the prospects here, Mr. Park said it was difficult to form an opinion, as there was some doubt as to the true source of the oil. It was probably the coal-seams underlying Mount Egmont; and this hypothesis was supported by the occurrence of fragments of the purest graphite among the *débris* on the flanks of Mount Egmont. This graphite was no doubt a coal or lignite altered by volcanic agencies. The bores put down at Taranaki were too shallow; and the question of payable oil could only be determined by further explorations.

Distillation of Oil-shale.—This was an important industry in Scotland, and he did not see why it should not become the same here. Professor Black had shown that the Orepuki shale is superior to the celebrated torbanite, as it yields forty-two gallons of crude oil and other valuable products to the ton of shale, against forty gallons returned by the latter. To insure the success of this industry it would be necessary to manufacture our own sulphuric acid and alkalies. In the so-called refractory sulphides on our goldfields, and the native-sulphur deposit at White Island, we had an abundance of the raw material. The production of the alkalies would follow as a natural consequence. Mr. Park said our bituminous shales were a valuable asset, which would no doubt yield large returns when the proper time came for their development.

Mr. McKay asked the writer of this paper whether he had noticed the presence of petroleum in the east coast district of Wellington: he said that, so far as described, gas-springs only seemed to occur. Mr. McKay

referred to the existence of a mineral spring on Sutherland's station on the Pahaoa River, which yielded inflammable gas, freely escaping from the older rocks of the district, and which had not been included by Mr. Park as gas-bearing. He thought that possibly the Blairlogie gas-spring might have its source in the same rocks. He thought the author had under-estimated the so-called oil-bearing belt at Poverty Bay at four to five miles, his idea being that in some places it was not far short of twenty-five miles in breadth.

Mr. Higginson pointed out that the distillation of oil from shale had been abandoned in Scotland, owing to the flooding of the market with oil from the Black Sea ports. He did not think it would pay to distil the oil in New Zealand. From what he observed he thought the prospects at Poverty Bay appeared good. Of course, it was now a question of quantity. The raw material was now in great favour for use in all kinds of steam-engines, and very startling results had been published. It would revolutionise the manufacture of small engines.

Mr. T. W. Kirk did not think there was much chance of the hopeful anticipations regarding oil-production in New Zealand indulged in by the author ever being realised—at any rate, for a great many years. In 1886 the export from Baku alone was over 870,000,000 gallons; America added 28,000,000 barrels of forty-two gallons each; and the supply from these places was still increasing: so that our being able to compete with the foreign article was unlikely.

Count Jouffroy d'Abbans hoped that when the Government sent the New Zealand minerals they had promised to the Paris Exhibition they would include specimens of the New Zealand petroleum and shales, so that they might be tested by the experts who would no doubt be present to report on such products.

Mr. A. S. Paterson (advocate, Edinburgh) regretted that, having just arrived in the colony, he was not a member of the Society, but hoped he might be allowed to answer some of the difficulties referred to in the discussion. Permission having been granted, Mr. Paterson stated that, having been lately in contact with the shale enterprise in Scotland, he was in a position to assure the Society that since the opening of the Baku wells, and, still earlier, the introduction into Scotland of American natural oils, the working of shale had enormously increased. This was due to the fact that shale was no longer distilled merely for the oil it contained, but was treated by a new process for ammonia and other products previously regarded as by-products of little or no value. At Burntisland, Straiton, and other places in the vicinity of the Firth of Forth, large works had sprung up, and gave large returns, in some instances 30 per cent. being earned. There had been difficulties with the workmen at Dalmeny and elsewhere, resulting in strikes of a disastrous character; but these were no indication of any loss of trade. It was a curious fact that for many years this valuable shale had been lying in strata exposed to public view in road and other cuttings in the vicinity of Edinburgh and elsewhere, but only within the last eight or ten years had its full value been discovered. He was not in a position to say that the New Zealand shale would give the same return when similarly treated; and, indeed, one specimen he had seen appeared to differ—at least, outwardly—from the best Scotch shale. He concluded by thanking those present for having heard him.

Mr. Gordon said that, with regard to Mr. Park's paper on the mineral oil in the Poverty Bay district, the author held out very little chance of success at the place where boring operations are now being carried on; but the reasons assigned did not appear sufficient to warrant this conclusion. Before we can tell definitely where petroleum is likely to be found we must understand its origin, and that is a subject on which scientists do not agree. We are pretty certain it is formed by the decomposition of

organic substances, but this need not be confined to the palæozoic rocks. A popular impression exists that the only rocks in our geological scale which contain carbonaceous remains are those of the carboniferous age; but Professor Peckham thinks it is very probable that carburetted-hydrogen gas and petroleum are derived from microscopic animals. When examining the oil-bearing strata in the Poverty Bay district lately, the question that occurred to him was whether the porous sands which contain the gas and oil were sufficiently thick to form reservoirs. There is no doubt as to the porosity of the seams on examining the strata in the gorge of the Waipaoa River: there are alternate bands of very porous sandstone, full of fissures and cracks, lying in almost a horizontal position among the calcareous marl. If thick porous beds of sandstone or limestone occur lying in the same manner where the oil is found they would form a large reservoir for the oil; therefore, before we can determine whether there is likely to be a good supply of oil obtained at the place where the present operations are carried on by the South Pacific Company, far more information is required to form data from which to give an opinion on the subject. He then read an extract from a paper read by Charles A. Ashburner before the American Institute of Mining Engineers: "In all geological ages prior to the carboniferous there did not exist sufficient land-vegetation to form extensive coal-beds; but the fossil remains of water-plants amply attest the fact that there was buried in the rocks below the carboniferous a great abundance of vegetable forms. Even in the Laurentian rocks of Canada, far below where I believe it is possible to find natural gas, there is a large accumulation of carbonaceous material in the form of graphite, which is now universally conceded to have been derived from the remains of vegetation. These plants belonged to the lower forms of vegetable life, as the animal remains of which many of our limestones are composed belonged to the lower forms of animal life. The latter are no doubt the source of the large amount of both oil and gas derived from the limestone beds. According to researches made by Professor Peckham in Southern California, the petroleum and gas there are very probably derived from microscopic animals."

In reply to Mr. McKay's questions, Mr. Park said that the gas-spring at Blairlogie occurred in the cretaceous rocks. As to the gas-spring at the Pahaoa River, the gas was sulphuretted hydrogen, which was inflammable, but no indication of oil. As to the average width of the oil-belt, he said that, although over twenty miles in some places, it was only a few chains at others. Five miles was a fair average. Mr. Park thanked Mr. Paterson for his valuable information regarding the shale industry in Scotland. He believed the shales of New Zealand would in time be turned to profitable account. In reply to Mr. Gordon, he said that petroleum occurred in rocks of all ages, from the silurian epoch up to the present time. The origin of the oil was not so important as the discovery of the strata which yielded it.

2. "On a Curious Feature in a Marsh Plant (*Glossostigma*)," by C. W. Lee. (*Transactions*, p. 108.)

3. "On the Production of Artificial Chromes for Ornamental Purposes," by W. Skey. (*Transactions*, p. 359.)

Fifth Meeting: *12th September, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

Papers.—1. "The Late Earthquake (1st September, 1888), and its Bearing on the Architecture of Wellington," by W. M. Maskell, F.R.M.S.

ABSTRACT.

The author, after alluding to the fact that the comparative immunity from destructive earthquakes enjoyed by the colony since 1855 had caused a general feeling of security, pointed out that no spot on the face of the earth is absolutely safe from earthquakes. When it was remembered that the most violent of all our New Zealand shakes happened in the neighbourhood of Wellington only about thirty-three years ago, and that a large portion of the Te Aro district in this city could probably not have been built over if that convulsion had not raised it several feet, one was inclined to wonder sometimes at the apathetic coolness of the inhabitants, and especially of the professional and municipal authorities. He was surprised to find that in the building by-laws of the City Council there was not, with one small exception relating to chimneys (which seemed to be a dead-letter), a word to indicate that any danger to life or property is to be feared from earthquakes. The Council seemed to have had a thorough dread of fires, but none of earthquakes. The City Surveyor had power to pull down chimneys built previously to the passing of the by-law if they caused "reasonable danger of fire," or from being built contrary to the provisions of the law; but no mention was made of earthquakes. All sorts of "architectural projections" were permitted on the outside of buildings, if approved by the City Surveyor, provided only they were placed high enough above the street. Professor Milne, of Japan, probably the highest living authority on the subject, had laid down the following principal rules to be kept in view in building stone or brick buildings in an earthquake country: (1.) So arrange the openings in a wall that for horizontal stresses the wall shall be of equal strength for all sections at right angles. (The meaning of this he took to be that it is better in buildings of several stories not to have the windows all arranged in regular vertical lines.) (2.) Avoid heavy-topped roofs and chimneys. (3.) Let archways curve into their abutments ("archways" here seeming to include window-openings). (4.) Place lintels over flat arches of brick or stone. (Seemingly, Professor Milne's suggestion was that these lintels should be of iron or timber.) Professor Milne also suggested that "to build high houses would be to erect structures for the first earthquake to make sport of." On the other hand, although there seemed to be nothing positively asserted as to foundations and solidity, it would appear that heavy solid buildings on deep foundations had less safety than light buildings on loose foundations. Criticizing some of the principal brick and stone buildings of Wellington in the light of the principles thus laid down, Mr. Maskell found that almost all these points appear to be neglected in at least the greater part of them. For example, in the Post-office, a building which looked as if designed to show how many windows could be arranged in the least space, the openings were placed in numerous vertical rows, their arches springing sharply from their abutments, and there was a heavy cornice running on the top of the somewhat thin walls. The large building of the National Mutual Insurance Company had also a heavy cornice, numbers of external ornamental projections, windows in vertical rows, and with arches not curved to the abutments. A building now in course of erection near the wharf had the brick partitions between the windows seemingly designed only to resist vertical pressure, and with little strength horizontally. The stupendous ugliness of the new Government Printing Office was such that perhaps even an earthquake might disdain to touch it: here again were vertical rows of windows with sharp-cornered arches, and a heavy pediment on each side. He understood, also, that this was a heavy, solid building, standing on very deep and strong foundations. Messrs. Harcourt's warehouse had the usual kind of windows, and would seem to the uninstructed eye to be dangerously lofty. In street buildings the openings, mostly very large on the ground-floors for shop-windows, had above them several others, generally so arranged as to give a weak appearance to the fronts. And in many cases imitation

vases, globes, groups of figures, and other ornamental devices were placed along the edges of the roofs. It should be recollected that in cases where, as in the Post-office, a building is nearly all windows and openings, the iron rods and bands used to tie brickwork together cannot possibly run continuously in the external walls. On the whole, an inspection of the brick and stone buildings in the town of Wellington leads the lay mind rather to the impression that architects—at least, up to the present—have laid less stress upon safety from earthquakes than on their ideas of artistic effect. The matter of chimneys interested not only the dwellers in brick houses, but also those in wooden houses. Past experience of earthquakes clearly set forth that, as wooden houses swing at different intervals from those of their brick chimneys, if these last are in contact with the timbers of the house they are very liable to be simply knocked down. Yet probably there was not one house in a thousand in Wellington where the chimney was not built closely touching the woodwork of the roof. In conclusion, Mr. Maskell said that in the face of past history scientific pundits might demonstrate quite to their own satisfaction that a destructive shake is not at all likely to occur in New Zealand, just as some people can show to a moral certainty that the world will come to an end in some particular year. Still, it did seem not quite satisfactory that the by-laws of the Wellington Corporation should contain no kind of provision against earthquakes, and that a glance at the buildings in our streets should show that the points mentioned by high authority as desirable should not have been taken into consideration.

Mr. A. McKay, Assistant Geologist, in discussing the paper, said that Wellington was more concerned in the recent shocks in the Amuri district than most people supposed. He referred to the late earthquakes as in some way connected with the great lines of fault that run parallel with the Kaikoura Mountains, and thought that further movements along some of them may have been the cause of the late disturbance. He mentioned that the principal fault-line was prolonged across Cook Strait into the North Island, and in the South Island extended to the south-west far beyond the boundaries of the Amuri district. It was not certain that our city might not be visited next, for most surely we stood on the same fracture-line, and it was only a question of place whether we had the violence of a shock at one time, and there was a lighter one in the South, or *vice versâ*. The line of fracture passed from Tinakori Road to the mouth of Happy Valley, was next seen across the Strait at Lake Grassmere, on the Flaxbourne Estate, where it was traced for about sixty miles, to the Hanmer district. It passed within one and a half miles of the residence of Mr. Low, which suffered so seriously in the late convulsion, and at no great distance from Mr. Rutherford's station. The downthrow in the Kaikoura district was not less than 10,000ft., but between Karori and the city it was only 500ft. All this displacement had taken place in comparatively modern times, geologically speaking—perhaps within 500,000 years—and the movement was certainly not likely to cease for a considerable period—perhaps another 500,000 years.

Mr. T. W. Kirk said that the best thanks of the Society were due to Mr. Maskell for having drawn attention to this subject. If the city had really the slightest claim to the title sometimes given it by persons from other parts of the colony—viz., the "city of wind and earthquakes"—then the paper should possess special interest for the citizens, and he was surprised there was not a much larger attendance: the absence of architects was particularly noticeable. The author stated that there had not been for more than thirty years, until the present month, any earthquakes in New Zealand of sufficient violence to do damage to property. He would like to ask Mr. Maskell if he did not think the earthquakes which accompanied the Tarawera eruption of sufficient violence. He thought it would have been as well if the candidates for seats at the City Council had been present, for after Mr. Maskell's paper

was made public they would most likely be asked to give their opinions on the architecture of Wellington. It seemed to him that a great deal more was made of the elevation of Te Aro flat than was necessary. Old residents had told him that the flat was originally a swamp, impassable except in a few places, and separated from the harbour by a bar; and that one winter there was an unusual accumulation of water in the swamp, with the result that it swept the bar away. From that time the flat ceased to be a swamp of any great extent, and subsequently drainage arrangements were carried out. The earthquake no doubt assisted in the alteration, but he thought it was the accident of the carrying-away of the bar that had most to do with rendering Te Aro flat available for building purposes.

Mr. H. P. Higginson thought that most of the defects in architecture pointed out by Mr. Maskell were the faults of the property-owners rather than of the architects. They insisted upon having structures of a certain class, and getting as much show as possible for their money. The immunity of Wellington from damage was probably due to the fact that the brick-work put up here was of a more substantial character than that in most other parts of the colony, particularly strong cement being used. Where the effects of earthquakes were felt most severely they were generally due in the main to bad workmanship.

Mr. Natusch (architect) said that, since reference had been made to the absence of architects, perhaps he might be permitted, although not a member of the Society, to say a few words upon the subject. Permission having been given, he said that when he arrived here some two years ago he naturally made it a point to ascertain what special provisions were made against earthquakes. He was astonished to find none; and, moreover, in course of conversation with Wellington men they said, "We have plenty of shocks—mere tremors; but there has not been a severe shock since 1855, when Te Aro was raised;" and it seemed to be generally taken for granted that serious earthquakes need not be anticipated. However, this hardly seemed reasonable to him; and, after considering the subject, he came to the conclusion that no more effectual "earthquake-proof" building could be devised than on the principle of framing. That is to say: Erect the frame of the building with wood, or with light T or angle-iron if preferred, very much in the same way as wooden houses are now erected; but on the outside of the framing secure thin slabs of concrete, with joints somewhat similar to those of rusticated boarding. Thus, in the event of a severe shock, the framing itself would sway more or less as the frames of wooden buildings do, and the slabs, having loose although weathertight joints, would also move with the frame. And he ventured to say that, except with a very severe shock (such a shock as would demolish the town), no damage would be done, and even if any of the slabs should be broken or cracked, they could be unscrewed and replaced with new at a trifling expense. Two or three people to whom he mentioned this were aghast at the idea of ugly buildings being put up with slabs of concrete. At first sight such an idea was quite pardonable even to the average architect or builder. But, in reality, architectural effects in any style, from the simple and pleasing Gothic to the most elaborate Roman or Grecian designs, might be produced. So much for the exterior. The interior could be finished with thinner slabs of the same material for walls, and the ceilings could be either plastered in the ordinary way, or formed with the patent steel webbing and plaster, which, in the event of a severe shock of earthquake, *might when old* hang down as old scrim does, but would not fall, as the ordinary plastered ceilings would do under similar circumstances. It would be seen, therefore, that buildings might easily be made to all intents and purposes "earthquake-proof." The fears of the City Council as to the advisability of permitting the use of wood framings should give way before the fact that fire could not possibly touch the wood, because it would be encased

with the non-inflammable concrete on both sides. Well, it had been said, "But surely such a method of construction would be precluded by the expense." But no; for one of the great beauties of this method was that it was more economical than building with brick or stone or solid concrete. His only objection to the method was the weight of the concrete. Happily this objection had been overcome in a highly satisfactory manner by Mr. Donaldson. A friend of Mr. Lascelles, the patentee of the system of building with concrete slabs in England—adopted, by the way, principally upon the score of economy, earthquakes not being usual in England—Mr. Donaldson, upon arriving here, set to work to improve upon Lascelles's system of manufacturing the concrete. By using pumice-sand with the best Portland cement, a concrete is produced which is of a much better natural colour, and, what is of greater importance, much lighter in weight than those made in the ordinary way. According to the proportion of cement used different degrees of hardness can be obtained, from that equal to Oamaru stone to granite. Thus, then, no obstacle so far as material, method of construction, and expense would stand in the way of this method for erecting both earthquake- and fire-proof buildings being adopted. What obstacle remained, then? Really none. But, as Mr. Higginson pointed out, architects are very much handicapped. In the first place, the City Council's by-laws merely provide against fire, by compelling the use of brick and stone, or solid concrete walls erected in the ordinary way, in the business quarters of the town; and he considered that the Council should be asked to permit the method of building in the manner pointed out. In the second place, those intending to build were afraid to go out of the beaten track, and architects were afraid to push home to their clients any such vital changes.

Mr. Donaldson also asked permission to speak, and said the problem of building houses sufficiently fire-proof, wind-proof, damp-proof, and earthquake-proof requires very careful consideration. In the first place, heavy materials such as stone and brick are more easily overturned than wooden structures, because if thrown slightly out of the perpendicular by an earthquake-shock their weight tends directly to bring them down, whereas a wooden structure with a properly-joined framework would bear a very considerable oscillation without any great effect being produced. But the objections to wooden buildings are,—

(1.) They are dangerous in case of fire.
(2.) They are not wind- or vermin-proof.
(3.) They rapidly deteriorate after being up a few years, and are too expensive to keep in repair.

The question therefore naturally arises: Can houses be erected with the tensile strength of a wooden framework, with a light yet strong material for the walls, proof against earthquake-shocks, as near as possible fire-proof, at the same time to exclude damp and wind, and offer great resistance to wear and tear? The method of construction used in iron-ship building answers all these requirements; but to build houses of thick plates of iron fastened on an iron framework would be very expensive, and the iron plates, being rapid conductors of heat and cold, would make such houses very uncomfortable. With a view to meet the requirements of the case, he had patented a concrete slab, made of a mixture of strong cement, pumice-sand, and sometimes gas-coke. This meets all the requirements. Samples of this material he exhibited. It has the following advantages:—

(1.) Unlike ordinary concrete, *it is homogeneous*, can be cut with a chisel or saw, can bear holes being drilled in it, and is perfectly uniform in strength.
(2.) It is fireproof. The slabs can be heated to a red heat without injury.
(3.) These slabs are made generally 1in. to 1½in. thick, and can be fastened to the studs in an ordinary wooden framework by

2½in. screws passing through holes bored in the slabs. These holes are so made that the heads of the screws are sunk below the surface of the slab, and are then covered over with the patent concrete material used as a plaster. (If these slabs are used on the outside and the inside of the studs, leaving an air-space between, and also on the floors and ceilings, a perfect fireproof structure is obtained, the timber framework being completely protected from fire by the slabs.)

(4.) The natural colour of these slabs is somewhat lighter than Bath or Oamaru stone. They can be supplied, however, of any colour, and the most elaborate ornamentation can be moulded on them.

(5.) Besides being wind- and weather-proof to a more perfect extent than either wooden, stone, or brick buildings, and being also earthquake- and fire-proof, these houses have the advantage that, should damage from any cause be done to a wall, no effect is produced on the slabs above or in the neighbourhood. Each slab is supported quite independently of every other slab. Damage is, however, very unlikely, as the slabs are strong and tough.

Mr. C. T. Richardson pointed out that the old hospital, which was now removed, was built somewhat after the plan advocated by Mr. Donaldson—namely, with what was called brick "nogging," a kind of framework built in with brick. Upon the fact being brought before the City Council they had provided that any one could build in the city after the same style.

Mr. Natusch: That only applies to No. 2 Building District, not to No. 1.

Mr. Brandon said that the City Councillors were not all architects or builders, and they had to frame their by-laws in a negative form. Of the two great dangers which they had to face, fire seemed more imminent than earthquakes, so they prohibited the erection of wooden buildings in the more populous parts of the city. They did not consider that it was necessary to detail the several points to be observed in the construction of buildings, so they left that part to the owners and architects. If the Council had endeavoured to frame by-laws to guide people in erecting structures warranted to resist earthquakes they would probably have laid themselves open to a great deal more criticism than they are now subjected to. As to the Post-office and Government Printing-office, the Government did not consider themselves bound in any way by the City by-laws, and would have gone on in their own sweet way in spite of the most earthquake-resisting regulations. Mr. Kirk had thrown some doubt on the raising of the ground at Te Aro on the occasion of the earthquake of 1855; but he believed he was right in saying that on the eastern coast of the province the beach was undoubtedly raised some 12ft., enabling settlers to ride round the coast where they had formerly been obliged to climb over hills, while Te Aro flat was elevated 4ft. or 5ft. In conclusion, he could only regret that, according to Mr. McKay's account, we had still 9,500ft. to slip down.

The President was sorry that there were not more persons present who were acquainted with the technical part of the subject. Of course, his only knowledge of the subject was that of an ordinary layman. As to the elevation of Te Aro, it would be excessively uncomfortable for the residents if they had to go down again, even 4ft., and there was nothing that he knew of to show that the land would not go down in the next earthquake in the same way as it rose thirty-three years ago. He was very glad that last week's shake occurred at Amuri: if it had happened in Wellington it would have knocked down about half the buildings in the city. Professor Hutton had consoled the people of Christchurch with the assurance that the centre of the late shakes was so distant as to

render their city quite safe; but Mr. McKay had shown that Wellington was by no means so far from the fissure, but was, on the contrary, very much on the line of it. His only object had been to call attention to the fact that the buildings in Wellington were not put up with a view to resisting earthquakes. Some people might say that it was not necessary to keep this end in view, and if they thought so they were entitled to their opinions. He was glad to find that no serious objection had been taken to the views he had offered. Every one present seemed to agree that our buildings were not erected in such a manner as to provide against severe shakes; therefore, if those shakes came, the people of Wellington would only have themselves to thank.

2. "On the Extent and Duration of Workable Coal in New Zealand," by James Park, F.G.S. (*Transactions*, p. 325.)

Mr. Higginson asked on what data Mr. Park's estimate of the amount of coal in each field was founded, and whether he had taken into account the depth to which the coal might be worked, and the probability of there being two or more seams of coal in the same field. He pointed out that a consideration of these facts would greatly affect the estimated amount.

Mr. Park, in reply, said that his estimate was based upon the surveys made by the different geological workers who had examined and reported on the various coalfields, which only included such areas as were known to contain coal.

Mr. McKay did not think that Mr. Higginson's most important question had been answered—namely, as to the number of seams that might be present in particular coalfields.

Mr. Park further said that he had stated in his paper that there was usually but one seam near the base of the series; and that otherwise his estimate of the amount of coal had been based on what might be worked level-free.

Sixth Meeting: *3rd October, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

New Members.—Robert Donaldson, C. Y. O'Connor, Perceval Earle, Robert Caldwell.

Papers.—1. "On the Fallacy of the Electro-capillary Theory," by W. Skey. (*Transactions*, p. 363.)

2. "Further Notes on New Zealand *Desmidieæ*, with Descriptions of New Species," by W. M. Maskell, F.R.M.S. (*Transactions*, p. 3.)

3. "On the Occurrence of Native Lead at Collingwood, and its Association with Gold," by W. Skey. (*Transactions*, p. 367.)

4. "On Earthquakes and Architecture," by T. Turnbull, F.R.I.B.A., M.I.G.A., and A.C.A.

Abstract.

In opening, Mr. Turnbull explained that as Mr. Maskell had, in his paper on the same subject read at a previous meeting, with only one exception, criticized buildings of which he had been the architect, he felt

it was his bounden duty to those who had employed him to vindicate the faith he had in the stability of brick buildings, and to show as far as he could those gentlemen, as well as others, that their confidence in the foundations of our city was not misplaced; and also to prove that modern science had in architecture acquired sufficient knowledge of construction to be able to erect buildings capable of withstanding earthquakes even of a severer nature than they were ever likely to experience here. The subject was an important one, as, without sufficient confidence in the lasting stability of the buildings, those who made our cities would never attempt to erect any of a permanent character. Thus the progress of architecture would be checked, and the best index of our civilisation impaired. From this point of view the subject was not only an important but an interesting one. As Mr. Maskell had quoted Professor Milne, of Japan, as probably the best living authority, which from the tenor of his paper he (Mr. Maskell) evidently believed, Mr. Turnbull said he would refer to portions of the Professor's work on the effect of earthquakes on buildings, for the purpose of showing that he was not as infallible as Mr. Maskell would have them believe. When he (Mr. Turnbull) had read several chapters in that book he had come to the conclusion that the Professor, with all his talent, knew little or nothing of architectural construction, as he used words and phrases that were unknown in practice; and nowhere did he give any specific information as to the mode of construction, or the qualities of the material used in the buildings injured, but contented himself with stating whether of brick or stone, and often not so much. He then quoted the Professor's works at some length, and endeavoured to show that he was not so much an authority as Mr. Maskell would have them believe he was. He referred especially to one statement made by the Professor, "that a civil engineer, writing about the New Zealand earthquake of 1855, when all the brick buildings in Wellington were overthrown, says that it was most violent on the sides of the hill, and least so in the centre of the plains." The Professor had quoted this from the report of the British Association of 1858. Now, they all knew this sweeping assertion to be wide of the truth; and they might well ask, What about the rest of the Professor's quotations? Seeing this assertion had been made from such a source, and repeated in such a book as the Professor's, he had made inquiries concerning the earthquakes of much-abused Wellington; and he mentioned Messrs. T. McKenzie and J. Plimmer in particular. There had only been three earthquakes of any consequence since 1840—namely, in 1840, 1848, and 1855. The earthquake of 1848 was of a much more severe character than the one in 1840, and many of the brick buildings in the city were shattered. Mr. Fitzherbert's free and bonded store in Farish Street collapsed, but was subsequently restored by Mr. Plimmer without taking off a slate. The front wall of the Colonial Hospital, in Pipitea Street, was partly thrown out. A new brick building on Mount Cook had to be stopped in consequence of the shake. Hickson's store, which was also damaged, is still standing at the corner of Old Custom-house and Cornhill Streets. The Wesley Church, in Manners Street, was also thrown down. These were all the brick buildings injured. It was worthy of note that no wooden buildings were injured. The brick buildings were built then of a mortar composed of shell-lime and clay from Barrett's Point, which with age was reduced to a powder. Old intelligent pioneers assured him that, if the buildings had been constructed then as they are now, little or no damage would have been done. A sensational report of this earthquake was drawn up by Mr. Eyre, Lieutenant-Governor, which had a most alarming effect, and greatly retarded colonisation for a long time. With respect to the shock of 1855, he had been assured that no brick buildings were totally wrecked, though some few were injured—in fact, buildings erected before that time were standing yet. Since Mr. Maskell had read his paper the author had visited them, and found them

in good order, and answering the purposes for which they were erected. As to the question whether it was possible to erect brick buildings in New Zealand, and in Wellington in particular, capable of resisting earthquakes even of a severer nature than any they had hitherto experienced, he said he had no hesitation in saying that it was, and that buildings of such a character were erected. As Mr. Maskell had referred to several of the buildings erected under his (Mr. Turnbull's) care, he desired to say something respecting them. Concerning Messrs. W. and G. Turnbull's building on the reclaimed land, he stated that he had suggested floating foundations, as they were not costly, had stood the earthquakes well in San Francisco, and the filled-in earthwork between the rock below and the foundations of the building would act as a cushion, and deaden the stroke of an earthquake should one occur. This foundation consisted of cross-planking and a double row of beams all bolted together. The motive for this system of foundation was that when a shake occurred the heavy beams and planking would carry the superstructure along with the oscillations of the earthquake. When this building was in course of erection an earthquake occurred. This was at a time when our Solons were in session; and many of them rushed down to the reclaimed land expecting to see the buildings in ruins, and he supposed they were somewhat disgusted to see the mechanics at work as if nothing had happened, so little knowledge had they of the strength and tenacity of brick buildings. He mentioned this to show that even the siftings of the New Zealand population had little faith at that time in the stability of brick structures in Wellington. He entered into the question of cements, and the most suitable, in his opinion, to be used here, recommending "béton aggloméré." Referring to the qualities of New Zealand timbers, he said they had little or no fibre, and broke short without warning. Some of the varieties were never seasoned, and the most useful and best shrunk the end-way, to the disgust of the architect and builder. Mr. Maskell said that the National Mutual Association buildings had a heavy cornice to their projections, and that the arches did not curve into the abutments. He said the same of the Post-office. Now, in each of those buildings the cornices projected just 6in. less than, according to the best authorities, they should do in order to produce true architectural beauty. He noted this to show that he had erred on Mr. Maskell's side—if error it was. In his opinion, however, the line of 6in. more could have been touched with perfect safety, as the roof behind was infinitely more than a counterbalancing weight, as was shown by the naked walls of the Post-office having stood for the last eighteen months without floor or roof, and after being exposed to extreme heat. So far as the arches were concerned, they all curved to the abutments, for the reason that there was nowhere else to butt them to. For the safety of the building now he could not answer; but before it was destroyed by fire he would have stood in any part of it during the severest shakes he had felt here or on the west coast of America, and have had perfect confidence in his safety. He denied Mr. Maskell's assertion that buildings were not put up in Wellington to resist earthquakes. Here, as elsewhere, money entered largely into the qualities of a building; and, speaking personally, he used to the utmost every precaution that the money at his disposal would allow him, and he was sure that his contemporaries would do the same for their own sakes; therefore it was neither just nor fair to an honourable profession to make such an assertion—not even by a gentleman who confessed that he knew nothing about it. He agreed with Mr. Maskell that the Corporation by-laws ought to be more explicit. There was not one word about the quality of the brick or of the mortar, or how they were to be laid together, and other important matters. Clearly, their City Fathers had paid more attention to the fire-insurance agents than to earthquake-agitation. He thought it was time that the city should have a Building Inspector who

knew something about building-construction. He suggested that on the reclaimed land floating foundations should be used as a protection against earthquakes. The bricks should be hard and square, and well wetted, and the mortar should be composed of what is called "béton aggloméré" in France. Hoop-iron should be built in the walls at short heights, and the buildings girt with bond-irons instead of wall-plates. The joists should be a fifth of their depth in thickness, and supplied with wrought-iron anchors. Mr. Maskell had told them that he had taken opportunities of looking at some of the brick buildings in the city, and had found that the greater part of the theories of Professor Milne had been neglected. He hoped that he (Mr. Maskell) would now admit that in these visits his looking was only superficial, that he only saw regular openings one over the other, instead of scattered ones, that the arches were not curved into the abutments, and that there were some projections which did not please him. He hoped that, after having heard the foregoing general description of the construction of the buildings under consideration, Mr. Maskell would see that the wrought-iron built within the walls, and the iron-bound connection that the floor and roof had with the walls, formed such a tower of strength as even Professor Milne never dreamt of. All his (Milne's) theories were mostly on the face, and no part of the framework. This system had been followed in the building he (Mr. Maskell) had criticized. It was a mode of construction that had proved eminently efficient in San Francisco and along that coast, and was in use with the architects there, a body of gentlemen represented by every nation in Europe, as well as America, and who had begun the study of earthquake-proof construction long years before the name of John Milne was known to the scientific world, who were still continuing the study, and on this subject were, in his opinion, the best authorities on the face of the earth. In conclusion, he hoped there was nothing in Mr. Maskell's paper or Professor Milne's book that would eliminate the faith they had in their adopted country, and that they would continue to hope that they would experience no more severe tremors of the earth in the future than they had in the past.

Mr. Donaldson asked the author whether the wooden buildings stood the shakes experienced in 1848 and 1855 better than those of brick or stone.

The President regretted that Mr. Turnbull had made the question a personal one. He (Mr. Maskell) had carefully avoided that; and his only object in presenting the paper was to draw public attention to an important matter. He did not desire to defend Professor Milne, who could stand up for himself; but if he was allowed he would differ from Mr. Turnbull's opinion of that gentleman. As far as his (Mr. Maskell's) reading went—and it was not that of a few days—no name stood so high as that of Professor Milne upon such matters. He combated Mr. Turnbull's arguments at some length, and pointed out that the effects and results of earthquakes were incomprehensible. Earthquakes seemed to knock buildings down or leave them alone just as they liked. A number of buildings on one side of a street might be knocked down, while others on the opposite side would be uninjured. He considered that Mr. Turnbull had given up the whole question—just as an architect who had written to a newspaper in reply to his (Mr. Maskell's) paper had done—by expressing the opinion that we were not likely to again experience destructive earthquakes. Those who thought that were perfectly welcome to their opinions. He did not believe that destructive earthquakes might not at any time occur in New Zealand; and he explained that the whole of his paper was based on the supposition that what had happened before would probably happen again. He quoted some notes on the shock of 1848, written by Mr. W. Fitzherbert, who stated that "the earth in some parts was moved in waves averaging about 12in. in height." He would like to know how their brick buildings would fare under those

circumstances. Mr. Fitzherbert had further stated that in the brick buildings which were thrown down the mortar used seemed to make very little difference. In many cases it was bad; but where good cement had been used the only difference noted was that the bricks, instead of falling singly, came down in blocks of eight or ten together. This would probably not be much more satisfactory to the inmates than a rain of single bricks. Mr. Maskell also quoted from some notes on the same earthquake given by Mr. H. S. Chapman (afterwards Judge Chapman), in an article in the *Westminster Review*, detailing the damage done. In this article Mr. Chapman expressed the view that brick buildings in Wellington might be safe enough if of one story only, or well tied together by bonding-timbers, but not otherwise. Mr. Maskell expressed his belief that, if the recent shock experienced in Canterbury had occurred here, one-half the large buildings of brick and stone would have been very much injured, if they had not fallen down. Further, as a proof that men of eminence did not think the earthquake of 1848 a light matter, and considered great precautions necessary for the future, he quoted from a letter written in 1888 to the Institute of British Architects by Mr. E. Roberts, who was attached to the Royal Engineers in Wellington in 1848. Mr. Roberts after that built a new gaol on Mount Cook, and took the precaution of constructing it with specially large bricks built in a perfect cage of iron bars placed 5ft. apart, and running up from the foundation to the roof. This gaol is of no great height. Surely in structures such as we have now, of three or more stories, much greater precautions than those of Mr. Roberts should be adopted.

Mr. Turnbull, in reply, said that he did not mean to make the question a personal one. He explained that the Roman cement referred to was not equal to our present cement. He could not say much as to how the wooden buildings had stood during the severe shocks.

A collection of minerals from Richmond Hill, Collingwood, presented to the Museum by Mr. H. P. Washbourne, was exhibited. They comprised some beautiful specimens of tourmaline, steatite, tremolite, amphibole, and iron-pyrites.

Seventh Meeting: *17th October, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

Papers.—1. "Notes on the Decrease of the Pheasant in the More Settled Parts of the West Coast of the North Island," by E. N. Liffiton. (*Transactions*, p. 225.)

Mr. Higginson considered that the want of sufficient grain-food was one of the chief causes of the decrease.

Major Campbell said that in parts of the North where there were few wekas the pheasants increased, but as the small birds increased the pheasants seemed to disappear.

Mr. Coleman Phillips attributed the decrease of the pheasants to the large quantities of poisoned grain that had been spread. There were great numbers of hawks in the Wairarapa district, especially where the rabbits were, and these hawks kept the pheasants away. The pheasants would increase when the rabbits were cleared off.

Mr. Park said he was able to fully corroborate all the author had said with regard to the decrease of pheasants and the corresponding increase of wekas in the Wanganui district. Both lived under the same cover; and as the weka had developed a proclivity for pheasants' eggs it was quite obvious that the native game must ultimately drive out the

imported bird. He thought the author was quite justified in his conclusion that the weka was largely concerned in the decrease of the pheasant.

Mr. McKay would merely remark that in the Bay of Islands district, where there were no wekas, plenty of dogs, and hawks were very rare, the pheasant had almost disappeared, although once plentiful.

The President said there appeared, as he had contended on a former occasion, to be some kind of law by which birds or beasts introduced from other countries became exceedingly numerous for a time and then died away. An important question raised now was, whether such birds or beasts must not be preserved more strictly if they are intended to increase, instead of following the usual New Zealand principle of letting a thing "slide" after you had once obtained it.

2. "On the Takahe (*Notornis mantelli*) in West Otago," by J. Park, F.G.S. (*Transactions*, p. 226.)

The Hon. Mr. Mantell said that the western shores of Lake Te Anau were known to the primeval Maoris as "The Land of the Takahe." This bird was plentiful there in 1851, but the natives set a high value upon it, and were unwilling to procure specimens for Europeans.

Mr. McKay said that it was true, as described by Mr. Park, that the supposed bird was hunted by torchlight two successive nights at the camp on Cascade Creek, and several hours each night were devoted to this purpose; but the bird was never seen. For the first time he now became aware that the bird had been seen by Mr. Park. At the time, he (Mr. McKay) was under the impression that all three supposed it to be the moa, and such it was suggested it might be by both Dr. Hector and Dr. Buller at the first meeting of the Society after the return of the expedition.

In reply to Mr. McKay, Mr. Park said he could not be mistaken, as he had taken notes of the occurrences at the time. At Cascade Creek Mr. McKay devoted very little time to hunting the strange bird, only assisting for a few minutes at the decoy-fire on the evening of the 22nd January. He did not join the camp at the Forks until the beginning of February, and was absent when the incidents narrated took place. In arriving at the conclusion that the strange bird was the *Notornis* Mr. Park said he was largely guided by the opinion of Mr. Buchanan, who was an accomplished naturalist. Some time after this Dr. Hector suggested it might be the *Aptornis*.

3. "The Knowledge of Cattle among the Ancient Polynesians," by E. Tregear, F.R.G.S. (*Transactions*, p. 447.)

Mr. Coleman Phillips, whilst congratulating Mr. Tregear upon the research which his paper displayed, took exception to its heading. He had attended this meeting of the Society especially to hear what Mr. Tregear had to say upon "The Knowledge of Cattle among the Ancient Polynesians." That was the heading of the paper. What he had heard was really very little else than a philological paper. Mr. Tregear's paper was actually a following of the root "*ak*" (from "*yak*," the cow of the Oxus people, the generally-accepted early home of the Aryan race) through the different languages of the earth. In his opinion the paper this evening should have been so called. It was scarcely fair, either to the subject or to Mr. Tregear himself—the able author of the paper—to name it otherwise. A considerable amount of doubt was expressed concerning all Mr. Tregear's philological investigations, owing to the fact that he endeavoured to confine them strictly to New Zealand or Polynesia. In Polynesia Mr. Phillips knew almost for a certainty that the *present* race of people there knew nothing whatever about cattle. He remembered in 1872 taking a ride of about twelve miles along the eastern

coast of Viti Levu, in Fiji, upon the first horse sent down to a plantation there in which he was then interested. The marvel of the natives, who had never seen a horse, and their screams of astonishment as he cantered past the villages, were most amusing. The missionaries had told them of a bull and of a cow. Some of them may have seen these animals. But he only knew that the children ran screaming away, with the cry of "Bullumakau! Bullumakau!" They joined the names of bull and cow together, and so dubbed the horse. This fairly showed the state of knowledge of the present race of Polynesia upon the subject of cattle. As to the ancient race, Mr. Phillips pointed out that the languages of the present Polynesian might not have been used at all by the ancient race—that race of stone-builders which left behind the cyclopean remains still existing in the Carolines, the gigantic images of stone men still seen in Easter Island, the monoliths and trinoliths of Tonga, the remains of aqueducts in New Caledonia, &c. The present race of Polynesians knew positively nothing about these ancient stone-builders. Mr. Tregear's use of the word "ancient" was therefore scarcely warranted. He quite recognised the value of Mr. Tregear's work, and encouraged him to proceed in it; but he would prefer Mr. Tregear to treat it as a linguistic study.

In answer to Mr. Phillips, Mr. Tregear said he had little to say to Mr. Phillips's argument. As to the Polynesians being a stone-building people, although in Hawaii they had temples of stone, &c., yet in New Zealand there had never been one stone put on another in prehistoric times—a proof that before the separation they had not been a stone-using people. As to Mr. Phillips being qualified to speak about ancient Polynesians because he had spent some time in Fiji, Fiji was inhabited by a Melanesian people of different origin from that of the Maori, and Fiji was not a Polynesian island at all.

4. "On the Ancient Moa-hunters at Waingongoro," by Colonel McDonnell; communicated by J. Park. (*Transactions*, p. 438.)

The President said that this was a question that had caused a great deal of argument. Sir Julius von Haast, Mr. Colenso, and others had taken one side (arguing that the moa was extinct before the Maoris came to New Zealand); while Mr. Mantell, Sir James Hector, and others had taken the other. He expressed surprise that Mr. Colenso should found a theory on the circumstance that there were no traditions or legends to prove otherwise, and questioned whether these traditions were of any value at all. Certainly he thought the testimony of a man who had actually seen and eaten the moa was worth ten thousand legends and traditions.

Mr. Tregear said that, although not prepared that night to speak on this question at length, a paper of his on "The Maori and the Moa" had been read before the Anthropological Society of London in May this year, and to prepare for this he had read up every available authority. His conclusions were that the Maori had never seen the moa; that his knowledge of the subject (if he had any knowledge) was traditional, and gathered from some older race inhabiting the islands when the Maori arrived, and absorbed by him. The negative evidence was very strong; the absence of any distinct notice of the huge birds in hunting-legends, and in descriptions of food-supplies, was very noticeable. The moa spoken of in the vague and fragmentary allusions to be found might have been any bird, large or small. In reply to Mr. Maskell, he would state that the comparison of native legends to worthless fairy-tales was unfortunate, because some of the most valuable evidence of the remote lives of our ancestors was being gathered together by comparative mythologists from fairy-tales, and it had been found that even nursery rhymes had

passed from mouth to mouth unaltered for ages. Literature corrupted tradition; and the semi-religious manner in which old songs and charms were handed down from priest to priest and from father to son gave them a value for accuracy beside which our current gossiping way of telling narratives or of compiling history was loose and valueless. Only those who knew and loved the investigations were competent to understand their value.

Mr. Park read an extract from a paper by the Rev. R. Taylor, which he said had a direct bearing on Colonel McDonnell's paper, and confirmed the incidents described by that author. Mr. Taylor describes how he visited Waingongoro in 1843, and again in 1866 in company with Sir George Grey, when he collected burnt moa-bones and obsidian-flakes, which were plentiful in the old Maori ovens at that place. Mr. Park said that the late Sir Julius von Haast always held the opinion that the moa was exterminated by an aboriginal race of Polynesian origin that inhabited New Zealand before the arrival of the Maoris. This theory, however, was based on two assumptions which had yet to be substantiated —first, that such a race did at one time occupy New Zealand; and, second, that the Maoris did not kill and eat moas. Mr. McKay, who assisted in the exploration of Sumner Cave, near Christchurch, went a little further and expressed the opinion that the extermination of the moa was the first work of the Maoris on their arrival in this country. In view of the researches of Mr. Mantell and Mr. Taylor, Mr. Park thought Mr. McKay might have gone further. It seemed now to be beyond dispute that the moa lived down into what might be called historical times.

The further discussion of this paper was adjourned.

Eighth Meeting: *14th November, 1888.*

W. M. Maskell, F.R.M.S., President, in the chair.

Papers.—1. Adjourned discussion of Colonel McDonnell's paper on "Moa-hunting."

Mr. Tregear, speaking from some notes he had prepared, said he did not wish to impugn for a moment the good faith of Colonel McDonnell, who had doubtless presented the evidence as supplied to him, but he protested against such evidence being published as reliable. The first discoverers of moa-remains, Messrs. Colenso, Mantell, and Taylor, had been not only keen lovers of science but accomplished linguists; and they had exhausted every variety of research in trying to get reliable evidence from the oldest Maoris forty years ago, with the result that Mr. Colenso, in his learned paper on the subject, stated that if the Maoris had ever known the moa it must have been in very ancient days. He came to this conclusion from the absence of allusion to the great bird in combats of deities and heroes with monsters; from the absence of mention in hunting-stories and lists of food-supplies; from the absence of moa-feathers on garments (while cloaks of kiwi- and albatross-feathers and of dogs' tails were prized); and from the mythical character given to the bird, as being found on a mountain guarded by huge lizards, &c. The old leading chiefs to whom he (Mr. Colenso) wrote said that "neither they nor their forefathers had ever known the moa." The speaker said that they were too apt to consider the New Zealand Maori as a unique animal: he was only a member of the Polynesian nation; and, as everywhere in Polynesia the word "moa" is used for the domestic fowl, it was probable that the Maori also once knew the fowl as "moa." The compound words containing *moa* were plainly, in Polynesia, references to the cock, as "cou-

rageous," "polygamous," &c.; and, as many of these compound words were also used by Maoris, it is probable that they had no reference whatever to the *Dinornis;* certainly the Tongan, Tahitian, Samoan, &c., words did not apply to the *Dinornis*. Nor did the scanty allusions in New Zealand song and proverb ever mention any attribute (such as huge size, &c.) of the bird—it might have been any bird. He believed that the pictures and descriptions of the bird sent (as reconstructed by Professor Owen) to every Maori tribe had been fitted to old traditions of *a* lost bird. Certainly it was monstrous that, when every effort had been made to get reliable evidence thirty years ago, a story should now be brought forward asserting that Kawaua Paipai (who only died four years ago) and his tribe hunted the moa in droves at Rangatapu. He (Mr. Tregear) had interviewed that day a number of old Maoris—one a centenarian—who had known Kawaua Paipai all their lives, and who had lived in Taranaki Province; and they laughed to scorn the idea of moas being "battued" on the Waimate Plains and they not having heard of such an occurrence. It was much easier to tell an untruth than to hunt moas in modern days.

Sir James Hector was astonished at this fruitless discussion being revived. Mr. Tregear had not gone back far enough in our "Transactions," or he would have found Mr. Colenso's reports of earlier date than 1878 referred to. In 1840 Mr. Colenso relates that he himself had gone out with a party of natives expecting to capture a live moa. He would also have found the reference to Polack's account of the large struthious bird called the "moa," gathered from native tradition long before any bones had been described. The manner in which the moa-bones were found associated with remains of human occupation throughout New Zealand afforded clear evidence that these huge birds had been eaten and exterminated by a race that could not be distinguished by any habits of life from the Maoris of a few years ago. The determination of the epoch of the first appearance and the date of the final disappearance of the moa was more a question for a geologist than a philologist. The paucity of reference to the moa and its true nature in the early collected vocabularies was due to the circumstance that those who questioned the Maoris had no conception of the existence of such an extraordinary bird, while to the Maoris it was such common information that they never thought of mentioning it. Bishop Hadfield had explained this to him. But there were many allusions and traditions that referred to the moa. Certainly it was more rational to hold that the word "moa," as used by the Maoris, referred to the large birds that were so abundant than to a domestic fowl, of the existence of which in New Zealand until of late years there was not a scrap of evidence. He would remind the Society that in 1876, in this room, he had exhibited a feather with an after-plume, exactly agreeing with the feathers found on the moa's neck at Clyde, in Otago, and which feather he had taken off an ancient *taiaha* in the British Museum collection. As to direct evidence, he could only say that the great chief Rewi told him that his grandfather had killed moas.

Mr. Higginson said that he had seen in the York Museum the moa's neck and skin referred to, and its state of preservation did not give the impression that it was of very ancient date. The last recorded occurrence of the dodo in Mauritius was in 1680, and yet few or none of its bones were found until he himself collected some in 1865; and until this latter date the existence of the dodo was almost doubted.

Mr. McKay said that Mr. Tregear had in effect said that the Maoris had no knowledge whatever of the moa. It must, however, be admitted that, in as far as the tools and implements of the moa-hunters could be put in evidence, they proved distinctly that the moa-hunter was identical with the Maori. The excavations in Moa-bone Cave, Sumner, showed this clearly. The antiquity of any particular deposit might or

might not be in favour of Mr. Tregear's contention, but the point raised in Colonel McDonnell's paper—namely, the probable survival of the moa to a very recent date—might be safely affirmed and supported by a variety of evidence. Bearing on this, Mr. McKay said that some years ago he had collected from a moa's nest discovered by him in the western district of Nelson, and which from its position was under conditions most unfavourable for preservation of the remains found, these being scarcely protected from the direct action of the weather, and not more than 2in. under the surface, being covered by a thin layer of leaves and decayed vegetable matter; yet the bones of a moa-chick were found in this nest, together with bones of small birds, lizards, and rats; and it could not well be that these had resisted destruction from time immemorial.

Major Gudgeon stated that it was quite certain that Kawaua Paipai did point out the ovens referred to and dig up the bones. The reason why the Maoris did not speak much about the moa was that the existence of the bird was looked upon as so much a matter of fact, and it was so common. There was very little tradition on the subject. In speaking of the forest at Te Wairoa, Hawke's Bay, a native had explained to him that it had been burned by firing the scrub in order to capture the moa; that the bird was easily frightened, and that the Maoris of old used to fire the fern and scrub round the birds, who would huddle together and fall an easy prey.

The President said it appeared to him that every discussion on this subject, especially perhaps the present one, added more and more weight to his argument that one direct statement of fact, one positive testimony, was worth a thousand negative theories drawn from absence of legends. The contention of Mr. Colenso, Mr. Tregear, and their friends simply amounted to saying to Maoris, "You lie when you tell us that you or your grandfather ever saw a moa, because other Maoris say nothing about those birds." Weaker logic could probably not be found anywhere.

2. "On some Gall-producing Insects in New Zealand," by W. M. Maskell, F.R.M.S. (*Transactions*, p. 253.)

3. "Notes on the *Lasioptera cerealis*," by G. V. Hudson.

ABSTRACT.

Mr. Hudson said that, in view of the extensive crops of rye which he understood were grown in the southern parts of New Zealand, he felt it his duty to bring before the Society a very serious insect-enemy to rye, which, although he believed it had not at present arrived in the colony, yet might reasonably be expected to appear at any moment. When he pointed out that this insect bears exactly the same relation to rye as the Hessian fly does to wheat and barley, its serious character would be at once understood, especially when we reflected that whole tracts of country in Russia are completely devastated by its attacks. It therefore behoved all farmers and others in charge of rye-crops to be on the look-out for any kind of disease in the plants during the coming summer. Any specimens which might be sent to him he would be very pleased to examine and report on, as he had descriptions of the insect and its mode of attack in his possession.

Sir J. Hector said, in reference to this subject he might state that Mr. Koebele, of the United States Agricultural Department, who had been specially sent to Australia to obtain the natural remedy for the *Icerya purchasi*, or wattle-blight, had been successful in securing the particular ichneumon-fly near Adelaide, and that he (Sir J. Hector) had arranged for a shipment being made to New Zealand at an early date. The society would remember that the *Icerya purchasi* was the remarkable Coccid described by our President some years ago, and which had proved

so destructive in Nelson and in most parts of the North Island except the Wellington District.

4. "Notes on Te Karamea Bluff," by Captain G. Mair.

Abstract.

Te Karamea Bluff is about a mile and a half south of Motuokura or Bare Island, and south of Cape Kidnappers some ten miles. It projects into the sea about 120 yards, and is joined to the mainland by a razor-back ridge of white marl, some 20ft. or 30ft. high and half the thickness. The highest part of the bluff is close on 100ft. It is formed of crumbling stone of every conceivable colour, red and chrome predominating. The whole mass appears to be resting on and slipping to seaward from a layer of marl. No other similar formation exists in the district, except in a small valley running parallel to the coast about a quarter of a mile west of the bluff, where there is a mound of the same material, about the size of a large haystack, cropping out on the hill-side. This place was formerly a refuge for the native tribes during war-time, as it is almost inaccessible. About 1828–30 a war-party of Ngatihoatua, from the Thames, under Takurua, who was afterwards killed at Kaipaki by Te Waharoa, laid siege to Te Karamea. The besieged were unable to lay in a store of food and water, and sustained themselves for a considerable time by occasionally lowering the most venturesome of their number into the sea at the outer end, who would collect limpets and seaweed from the rocks, and be drawn up the cliffs by ropes. Eventually they became so emaciated from want of food that the pa was taken, and a great massacre took place. The spot is now very sacred in the estimation of the natives living in the district. They had a whaling-station near by a few years ago, and a good boat-landing exists on the north or east side, according to the wind.

Mr. McKay said he was pleased that the paper had been read, more especially as it was evident the writer was unaware that a discussion on the true position of the red rocks had taken place; and yet the paper and sketch made it quite clear that these overlie the marl and greensand-beds of the isthmus and mainland. The evidence given in the paper was thus in agreement with what he himself reported in 1875, and again in 1886, and in no sense bore out the contention put forward by Professor Hutton that the rocks of Red Island—Te Karamea Bluff—are of palæozoic age, and are referable to the Rimutaka series.

5. "Remarks on Earthquakes in the Amuri District, South Island," by Alexander McKay, F.G.S.

Abstract.

The author commenced by stating that, for twelve months previous to the end of August last, booming noises, proceeding from the ground, had been heard in the district surrounding the Hanmer Plains, and that towards the end of that month earthquakes began to be experienced; these premonitions were followed by the great shock of the 1st September, which did nearly all the damage that happened to buildings, and opened most of the fissures that are yet to be seen. This was followed by the shock of the 28th September, and, after a like period, by that of the 23rd October, and those of the 26th and 28th of the same month; there being just about a lunar month between the first and second and the second and last series of shocks. Mr. McKay then described the effects the earthquakes had produced, and gave a detailed account descriptive of the fissures opened at many places along the Waiau-ua and Hope Valleys, more especially those seen near the mouth of Gorge Creek near Hopefield, at Hopefield, and at and near Glynn Wye. The present ruined condition of the buildings at Glynn Wye was described, and the manner in which the fences

had been broken and shifted 8 feet 6 inches to the east of the line in which they originally stood. Next it was shown that the evidences consisting of slips and earth-rents are confined to a narrow belt of country extending S.S.W. from the east corner of the Hanmer Plain to the Upper Hope Valley, abreast of and about six miles to the north of Lake Sumner, in the Hurunui Valley. Beyond this point to the westward the line of dislocation was not examined. All these rents and fractures lie along a line of previous earthquake disturbance, the old fractures indicating this being traceable on the surface where the line does not run along river-beds, liable to be flooded and leave the surface shingles rearranged. The eastern continuation of this line of old fractures caused by earthquakes was described as extending to the eastern base of Mount Fyffe, near Kaikoura. Glynn Wye was described as being the point on this line at which the most violent disturbance of the surface took place; while Westport, 60 miles to the north, Christchurch, 65 miles to the south, and Kaikoura on the east coast and Hokitika on the west coast, were the limits to which the earthquake extended as a shock violent enough to do damage to buildings, &c. Mr. McKay said that, while not touching the question what the primal cause of earthquakes may be, he felt sure that the Amuri earthquakes, in as far as they were expressed at the surface and had been studied by him, were due to crushing movements along the old earthquake-line; and he went on to show that in the northern part of the South Island, and, indeed, throughout the islands of New Zealand, there are many old faults, showing a great vertical displacement, running coincident with earthquake-rents opened but recently, though not for the first time. The whole of the northern part of the South Island, it was stated, was being elevated, and a series of parallel fractures gave relief to the resulting strain, which relief, at the moment of its happening, produced the earthquake.

Sir James Hector considered that this paper, as a simply-told narrative of the observed facts, would become classical in the literature of earthquakes, and he complimented the author on its excellence. He did not quite agree with all the author's deductions, however. The mere linear extension of fault-lines did not determine a liability to earthquakes. There must be a lateral stress or condition of strain in some part of the fault-line. As he had pointed out last year, a violent concussion might originate from a slickenside surface in a fault. He quite agreed that in this particular case there was nothing to connect this shock with volcanic action, present, past, or future. It seemed to be a localised fault-movement, no doubt produced by the jar of a wide-spreading earthquake-shock of the ordinary mild character.

Mr. McKay, in reply, stated that we could only deal with what was open to observation. The facts went to prove that from some point not far from Glynn Wye the force of the shock diminished in all directions; and practically there or thereabouts the centre of the disturbance must be placed. As to the influence of the great faults, it mattered little whether the earthquake produced the faults or the faultings were the cause of the earthquake—both were effects of a greater movement behind either or both; but, as the faults and earthquake-rents were in this district on the same lines, the earthquakes were always most severe in the near vicinity of those lines. Mr. McKay said he spoke not of the numerous lesser faults that are to be found all over the country, but of the five or six greater faults whose movements have stamped with peculiarity the physical features of the whole district.

Sir James Hector exhibited a specimen of Alumite from Australia, with the alum obtained from it. He explained that it had been discovered by Mr. J. H. Cox, late Assistant-Geologist.

NINTH MEETING: *9th January, 1889.*

W. M. Maskell, F.R.M.S., President, in the chair.

New Members.—H. Taperell, W. Herbert, H. W. Robinson, and George Denton.

Papers.—1. "A Note in reference to a Paper which appeared in Vol. xx. of the 'Transactions,' on 'Gravitation,'" by T. Wakelin, M.A.

ABSTRACT.

Lord Grimthorpe says that he copied the figures as for an iron jar from a well-known paper by Baily, P.R.H.S., who gave 6·8in. as height of mercury for glass jar. He subsequently worked out Baily's paper, and found a great mistake, which he says he has corrected in the new edition of the "Encyclopædia Britannica." This, however, is a mistake: the figures 6·8in. are uncorrected. The height should be 8½in. to 9in.

2. "On Sanitary Sewerage," by H. P. Higginson, M.Inst.C.E. (*Transactions*, p. 369.)

Mr. Maxwell considered that one of the chief merits of this scheme over others that had been proposed was that it would obviate the necessity of having contour-sewers at great depth, passing through private property, and causing great inconvenience and expense; and another advantage was that the ejectors could be placed in duplicate.

Sir J. Hector had always favoured this scheme. It dealt with what was absolutely necessary, and nothing more. There were, comparatively speaking, no gases given off as in the old system, and the drains were self-cleansing, and did not require to wait for a flood to wash them out. The perfect tightness of the drains was also a great recommendation, and the ease with which they could be laid without going to any great depth. It was a pity more information as to comparative cost had not been given. He had explained this system to the engineers in Melbourne, where it seemed unknown, and in which city the drainage was very imperfect.

Mr. Hughes did not think the cost of this system would be so much less as at first appeared, as there would have to be a separate system for surface-drainage. He was doubtful whether the houses would be entirely free from the return gas, as stated.

The Hon. R. Pharazyn did not think gas would escape. The separate drains for rain would not be expensive. This system seemed to have great advantages over, and to do away with many objections to, old drainage-plans. There would be no difficulty in procuring information as to the cost of establishing such a system in Wellington. The thanks of the public were due to Mr. Higginson for this practical paper.

Mr. Richardson thought it would be a good plan to try this scheme on a small scale before finally deciding as to its merits. He thought it would answer admirably.

Mr. Higginson, in reply to Mr. Maxwell, stated that the "Shone" system, applied to Wellington, would avoid the annoyance and expense attendant upon interference with private properties, as the sewers could be constructed entirely upon the street-lines. Mr. Clark's high-level contour-sewer, which for the greater part of its length passed through private land, would entail a heavy outlay for compensation.

In answer to Sir James Hector, the author said it was now accepted as a fact that the "separate" system enabled the size of the sewers to be properly proportioned, and avoided the necessity for constructing huge brick sewers in order to carry off an exceptional rainfall, the result being that in dry weather the flowing contents were represented by a

mere trickle along the invert of the sewer. This state of things resulted in the accumulation of deposit, owing to the velocity being insufficient. The outfall-main being under pressure, any leak is easily detected, and quite as easily repaired, owing to its being laid but little below the surface of the ground. The cost of applying the system to Wellington had purposely not been dealt with in the paper, as sufficient data from which to frame a reliable detail-estimate were not available. It might, however, be stated that, from such information as could be gathered from Mr. Clark's published report and other sources, and allowing for the reticulation of the whole forty-two miles of streets with properly-constructed sewers, laid on a concrete bed, provided with man-holes, lamp-holes, automatic flush-tanks, also for the whole of the necessary machinery, cast-iron mains, &c., the cost would not exceed £80,000, or 32s. per head for the 50,000 persons provided for; while the cost of Mr. Clark's scheme amounted to £145,000, or 41s. 5d. per head for the 70,000 persons provided for.

In reply to Mr. Hughes, Mr. Higginson agreed that to a certain extent the "separate" system necessitated duplicate sewers, but considered that over a large area of the suburbs it was possible to carry off the rainfall by the side-channels and short lengths of pipes into the nearest natural watercourses. In many cases the watercourses had been converted into sewers, but it was now proposed to re-convert them to their original use. It should also be remembered that the existing drains and sewers would be devoted to this purpose entirely, and that for the sewage a complete system of independent sewers is provided for in the estimate quoted. It would be impossible for sewer-gas to become generated between the dwellings and the ejectors, provided the sewers were laid to self-cleansing gradients. The area served by each ejector would contain no sewers more than 20 or 30 chains in length, so that, with a velocity given to the sewage of but 2ft. per second, only from 11 to 16 minutes would elapse before it had passed from the dwelling into the ejector, and become a thing of the past. It would therefore be seen that, unless a defect and stoppage existed in the sewers, there would not be time for gas to become generated. The system had been in constant use in Southampton and Warrington since 1884, where the officers in charge expressed to the author, when visiting the works, their entire approval. The town of Eastbourne was also drained upon this system in 1884, and, in a report published for the German Embassy by the Chairman of the Drainage Committee, that gentleman stated that they "have every reason to be satisfied with the works already executed on this system." A Select Committee of the House of Commons adopted the system in 1886 for the drainage of the Houses of Parliament, Westminster, where it had completely remedied the evils that previously existed.

In reply to Mr. Richardson, the author of the paper hoped that before long the system would be adopted on a small scale for the drainage of Pitone, when it would be possible to see the ejectors in action. As explained in the paper, the system could be adapted to suit the present requirements of a town, increasing the number of ejector-stations and main outfall-pipes so soon as the increased population warranted the expenditure.

In reply to the President, Mr. Higginson stated that he regretted he had omitted to mention that the air made use of in the ejectors was compressed by an ordinary air-compressing machine, driven by any suitable power available, and placed in the locality best adapted to meet the requirements of the particular case. This compressed air was conveyed by a line of small pipes to the different ejector-stations. It is usual to have only one compressing-station, the loss by friction in a long length of pipes being insignificant. In the proposed scheme for Wellington, the air-compressing station would be at the Corporation Yards, where either steam- or water-power would be available.

3. "On the Disappearance of Young Trout from our Streams," by W. Ferguson; communicated by T. W. Kirk. (*Transactions*, p. 235.)

4. "Note on a Rock Specimen collected by the Rev. W. S. Green near the Summit of Mount Cook," by Professor T. G. Bonney, F.R.S.; communicated by Professor Hutton. (*Transactions*, p. 334.)

Handsome and interesting specimens of Graptolites, which are interesting forms of great antiquity; also ores of copper and antimony from Nelson, and Alexandra, in Otago, collected by Mr. James Park, of the Geological Survey, were exhibited by the Director.

Annual Meeting: *18th February, 1889.*

W. M. Maskell, F.R.M.S., President, in the chair.

1. The Annual Report and Balance-sheet were read and adopted.

Abstract.

Ten general meetings had been held, at which thirty-one papers were read on the following subjects: Eight on geology, nine on zoology, one on botany, three on chemistry, and ten on miscellaneous subjects. A conversazione was held in the Museum on the occasion of the departure from the colony for a time of Mr. W. T. L. Travers, F.L.S. Thirteen new members had been elected during the year. The balance-sheet showed that the receipts, including the balance brought forward for the year, amounted to £206 18s. 2d., and the expenditure to £156 7s. 2d., leaving a balance in hand of £50 11s. The report and balance-sheet were adopted.

The report contained a proposal made by the President, with the view to the greater encouragement of research in the different departments of the Society's work, and it had been resolved to submit the following scheme for the approval of members: That the Society offer bronze medals, to be given annually for the best papers in the following groups: (1) Natural science (botany or zoology or geology of the New Zealand zoological sub-region), one medal; (2) physics, chemistry, and technical science, one medal; (3) history, archæology, and anthropology, one medal; (4) literature and philology, one medal; (5) philosophy; (6) art. That the Board of Governors of the New Zealand Institute be asked to appoint a judge in any group in each year for the papers competing in that group; that only those papers be submitted to the judges which shall have been read during the year at a meeting of the Society; that the writers of the papers must be members of the Society at the time the papers are read; that each writer must declare when sending in his paper if he wishes to compete; that the judges should be empowered to declare that in their opinion no paper of the year is sufficiently meritorious for a medal; that for the foregoing object the Society set apart annually £20 only of its income as a prize fund; that the medals be presented by the President at the first meeting of the Society ensuing after the receipt of the judge's awards; and that the Governors of the New Zealand Institute be requested to announce specially in the "Transactions" the names of the successful writers, though not necessarily to print the papers.

The scheme was, after discussion, adopted.

Mr. W. T. L. Travers moved a vote of thanks to the retiring President, Mr. Maskell, and in so doing referred to the great interest that gentleman had taken in the Society, and to the able manner in which he had carried out the duties of President. He also referred to Mr. Maskell's valuable contributions to the "Transactions"—especially to his work on the insect-pests now so numerous in the colony.

Mr. Maskell, in replying, referred to the visit to this colony of Mr. Albert Koebele, the German naturalist who had been despatched to the colonies by the American Government to investigate the presence of a parasite which feeds on the *Icerya purchasi*, and said he felt convinced that it was a matter of great importance to the colonies, as it certainly was one of most vital importance to the United States, where the ravages of the pests were enormous. Some years ago the blight was very prevalent in the Auckland, Napier, and Nelson districts, but it had never appeared in Wellington. In later years, however, he said, the natural enemies of the destructive blight had so rapidly increased as to render the pest now practically a thing of the past. He (the speaker), had been the first, about twelve years ago, to philosophically describe the pest. About six years ago a large valley near the Grafton Road, in Auckland, was literally a living mass of it, it being found by millions on every tree, shrub, and even gorse-bush; but lately he tried to get specimens in this valley, and was unable to get even half a dozen. This was in some respects also the case with the Napier district, and it he said, might be hailed with joy by growers of fruit. The blight was still prevalent in Nelson, but he had made arrangements to have some of the ladybirds—the insect which had taken to eating the *Icerya*—caught in Napier and forwarded to Nelson in order to stop the ravages of the blight in that quarter. He was sorry that the German naturalist he had mentioned could not be present at the meeting, but he had to leave Wellington yesterday for Napier, where he intended catching some hundreds of thousands of the ladybird-larvæ for transportation to America, and be in time for the American steamer leaving Auckland shortly. The facts which this gentleman had ascertained on the subject were exceedingly gratifying to the colonies and America, and, as the blight is gradually being got down, the fruit-growers may hope in a very short time to be able to grow their fruit free from this destructive insect.

Election of Officers for 1889.—*President*—Alfred de B. Brandon, B.A.; *Vice-Presidents*—Charles Hulke, F.C.S., Alexander McKay, F.G.S.; *Council*—Sir James Hector, Messrs. Govett, Travers, Tregear, Higginson, Maskell, and Hon. R. Pharazyn; *Secretary and Treasurer*—R. B. Gore; *Auditor*—T. King.

General Meeting.

New Members.—J. Duthie and C. H. Izard.

Papers.—1. "On the Electro-magnetism of Atmospheric Oxygen; its Causes, and some of its Effects," by the Hon. Robert Hart, M.L.C.

2. "Notes on some New Zealand Birds," by T. W. Kirk, F.R.M.S. (*Transactions*, p. 230.)

AUCKLAND INSTITUTE.

FIRST MEETING: *4th June, 1888.*

S. Percy Smith, F.R.G.S., President, in the chair.

New Member.—Rev. P. Walsh.

The President delivered the anniversary address.*

The President drew attention to a large and valuable collection of ethnological specimens from the Admiralty Islands, New Britain, and New Ireland, recently purchased for the Museum from Mr. G. Stuart, U.S. Vice-Consul.

SECOND MEETING: *18th June, 1888.*

S. Percy Smith, F.R.G.S., President, in the chair.

The Rev. E. H. Gulliver delivered a lecture entitled "The Realms of Imagination."

THIRD MEETING: *2nd July, 1888.*

S. Percy Smith, F.R.G.S., President, in the chair.

New Member.—H. F. Greenway.

Papers.—1. "Notice of the Capture of a Specimen of the Shy Albatross (*Diomedea cauta*) near Auckland," by T. F. Cheeseman, F.L.S. (*Transactions*, p. 125.)

2. "The Habits and Home of the Wandering Albatross," by A. Reischek, F.L.S. (*Transactions*, p. 126.)

Mr. Carlaw gave some interesting particulars respecting the nesting habits of the albatross, which he had gathered during a three months' visit to the Auckland Islands shortly after the wreck of the "General Grant."

3. "Poor-relief," by the Rev. W. Tebbs.

FOURTH MEETING: *16th July, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

Professor F. D. Brown delivered a lecture, with experimental illustrations, on "Electrolysis."

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* Printed already in *New Zealand Herald*, 5th June, 1888.

FIFTH MEETING: *30th July, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

New Members.—R. Heinitz, Dr. Wilkins.

Papers.—1. "New Beetles collected at Te Aroha by Mr. A. T. Urquhart," by Captain T. Broun.

2. "Notes on the Geology of Tongariro and the Taupo District," by Professor A. P. Thomas, F.L.S. (*Transactions*, p. 338.)

Lime-light illustrations, prepared from sketches made by Mrs. J. M. Clark, were shown at intervals during the reading of this paper.

3. "Notes on the Islands to the south of New Zealand," by A. Reischek, F.L.S. (*Transactions*, p. 378.)

SIXTH MEETING: *13th August, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

Mr. J. A. Pond, Colonial Analyst, gave a lecture on "The Chemistry of Agriculture."

SEVENTH MEETING: *27th August, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

New Member.—E. Bell.

Papers.—1. "On the Botany of Te Moehau Mountain, Cape Colville," by Jas. Adams, B.A. (*Transactions*, p. 32.)

2. "Darwinism tested by Logic," by R. H. Bakewell, M.D.

A discussion took place in which the Chairman, Professor Brown, Rev. J. Campbell, and Mr. J. Stewart spoke in support of the theory of evolution, and against the views expressed by Dr. Bakewell. Dr. Bakewell briefly replied.

EIGHTH MEETING: *10th September, 1888.*

Professor F. D. Brown in the chair.

Professor Thomas gave a lecture on "Micro-organisms, and their Power in Every-day Life," illustrated with lime-light views.

NINTH MEETING: *24th September, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

Papers.—1. "On some Birds from the Kermadec Islands," by T. F. Cheeseman, F.L.S. (*Transactions*, p. 121.)

2. "On the Visit of Captain Cook to Poverty Bay and Tolaga Bay," by Archdeacon W. L. Williams. (*Transactions*, p. 389.)

TENTH MEETING: *8th October, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

Dr. Challinor Purchas gave a lecture on "Optics."

ELEVENTH MEETING: *22nd October, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

Papers.—1. "On a New Species of *Gasteracantha* from Norfolk Island," by A. T. Urquhart. (*Transactions*, p. 152.)

2. "On New Species of *Araneidea*," by A. T. Urquhart. (*Transactions*, p. 134.)

3. "On the Mechanical Description of a Straight Line by means of Link-work," by Professor Aldis. (*Transactions*, p. 441.)

4. "On the Occurrence of Tellurium in the Lodes of the Upper Thames," by J. A. Pond. (*Transactions*, p. 358.)

5. "On the School of Agriculture, Lincoln," by A. Gray.

TWELFTH MEETING: *5th November, 1888.*

Professor A. P. Thomas, Vice-President, in the chair.

Dr. T. G. Davy gave a lecture on "Scientific Methods of Modern Pharmacology."

THIRTEENTH MEETING: *17th December, 1888.*

S. Percy Smith, F.R.G.S., President, in the chair.

Papers.—1. "On the Volcanic Rocks of Tongariro and the Taupo District," by Professor A. P. Thomas.

2. "On the Manganese Deposits of the Auckland District," by J. A. Pond. (*Transactions*, p. 355.)

3. "Notes on the Waikato River Basins," by L. Cussen. (*Transactions*, p. 406.)

ANNUAL GENERAL MEETING: *18th February, 1889.*

Professor A. P. Thomas, Vice-president, in the chair.

ABSTRACT OF ANNUAL REPORT.

Eight new members have been elected during the year. There have been several withdrawals, and the total number on the roll at the present time is 233.

The revenue for the year has been £970 10s., of which £171 3s. consisted of members' subscriptions, and £591 0s. 6d. interest on the investments of the Costley bequest. The expenditure reaches a total of £888 18s. 6d., leaving a balance of £81 11s. 6d. in hand. The invested funds o the Institute amount to £10,702, showing an increase of nearly £400 during the year.

Thirteen meetings have been held during the session, at which 25 papers on various scientific and literary subjects have been read.

Brief mention was made of the principal additions to the Museum and Library, and the various changes of importance in the arrangement of the collections were given in detail.

ELECTION OF OFFICERS FOR 1889.—*President*—Josiah Martin, F.G.S.; *Vice-presidents*—S. Percy Smith, F.R.G.S., Professor A. P. Thomas, F.L.S.; *Council*—Professor F. D. Brown, C. Cooper, Mr. Justice Gillies, W. Fidler, E. A. Mackechnie, T. Peacock, M.H.R., J. A. Pond, Rev. A. G. Purchas, M.R.C.S.E., J. B. Russell, Rev. W. Tebbs, Jas. Stewart; *Secretary and Treasurer*—T. F. Cheeseman, F.L.S., F.Z.S.; *Auditor*—J. Reid.

Attention was drawn to the recent departure of the late President of the Institute, Mr. Percy Smith, for Wellington, and several members spoke in reference to the valuable services rendered by him to the Institute during his many years' membership. It was agreed to present Mr. Smith with a valedictory address, and he was also elected an honorary member of the Institute.

On the motion of the Chairman, it was decided to present Mr. Reischek, the ornithologist, with an address previous to his departure for Europe.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

First Meeting: *2nd May, 1888.*

Professor F. W. Haslam, President, in the chair.

Mr. R. M. Laing was elected Secretary, *vice* Mr. W. Dinwiddie, resigned.

Second Meeting: *7th June, 1888.*

Mr. S. Hurst-Seager, Vice-president, in the chair.

New Member.—J. T. Meeson, B.A.

Third Meeting: *5th July, 1888.*

Mr. G. Hogben, M.A., Vice-president, in the chair.

New Member.—Gilbert King.

Fourth Meeting: *2nd August, 1888.*

Professor F. W. Haslam, President, in the chair.

New Members.—W. H. Graham and Thomas Danks.

Paper.—"On the Metallurgy of the Economic Minerals, Modes of determining them, and Methods of testing for them," by Mr. J. B. Stansell.

The following resolution was passed:—

The members of the Philosophical Institute of Canterbury desire to record the deep sense of the loss they have sustained in the removal by death of the late Thomas Henry Potts, who was one of the earliest members of the Institute, and contributed largely by his minute observation of nature to the knowledge of the natural history of New Zealand; and they request the President to write a letter of sympathy and condolence to Mrs. Potts and her family.

Fifth Meeting: *6th September, 1888.*

Professor F. W. Haslam, President, in the chair.

Paper.—"On the Goldfields of New Zealand," by Professor F. W. Hutton.

SIXTH MEETING: *4th October, 1888.*

Professor F. W. Haslam, President, in the chair.

New Member.—Dr. J. Townsend.

Papers.—1. "The Fall of the Leaf," by J. Rutland; communicated by Professor F. W. Hutton. (*Transactions*, p. 110.)

2. "The Earthquake in the Amuri," by Professor F. W. Hutton. (*Transactions*, p. 269.)

ANNUAL MEETING: *1st November, 1888.*

Professor F. W. Haslam, President, in the chair.

New Member.—H. O. Forbes.

The annual report and balance-sheet were read and adopted.

ABSTRACT.

During the session six ordinary meetings have been held, at which two papers were read and two lectures delivered.

In addition to the ordinary meetings, a course of popular lectures has been delivered under the auspices of the Institute, but only with a moderate amount of success.

During the session 5 new members have joined the Institute, and 16 names have been struck off the list.

The Institute has to deplore the removal by death of Mr. T. H. Potts, who was one of its earliest members, and contributed largely by his minute observation of nature to a knowledge of the natural history of New Zealand.

The Institute has obtained a valuable portrait of the late Sir Julius von Haast, painted by Mr. A. Cambridge. This has been hung in the library.

The balance-sheet shows a total receipt of £129 8s. 11d., and a total expenditure of £118 4s. 9d., leaving a credit balance of £11 4s. 2d. The reserve, consisting of the subscriptions of life-members, now amounts to £67 6s.

ELECTION OF OFFICERS FOR 1889.—*President*—H. R. Webb, F.R.M.S.; *Vice-presidents*—Professor F. W. Haslam, M.A.; S. Hurst-Seager, A.R.I.B.A.; *Secretary*—Robert M. Laing, M.A.; *Treasurer*—H. R. Webb, F.R.M.S.; *Council*—G. Hogben, M.A., J. T. Meeson, B.A., W. H. Symes, M.D., H. O. Forbes, Professor F. W. Hutton; *Auditor*—C. R. Blakiston.

The retiring President read an address entitled "The Restoration of Philosophy."

Paper.—"Descriptions of New Zealand *Micro-lepidoptera*," by E. Meyrick, B.A., F.E.S. (*Transactions*, p. 154.)

OTAGO INSTITUTE.

FIRST MEETING: *2nd May, 1888.*

A. Wilson, M.A., President, in the chair.

New Members.—John McLean (life-member), A. J. Barth, D. Wishart, Wm. Henderson, W. B. Buller, Edwin Sturmer, Maurice Joel, J. K. Paton, J. R. Don, W. E. Spencer; Drs. Fleming, Angus, and Stirling.

Professor J. Mainwaring Brown then delivered an address on "The Economic Position of New Zealand."

After numerous questions had been asked by members and replied to by Professor Brown, it was resolved to adjourn further discussion to a special meeting to be held on the following Tuesday. On the motion of Dr. Hocken, a hearty vote of thanks was accorded to Professor Brown for his address.

SECOND MEETING: *8th May, 1888.*

A. Wilson, M.A., President, in the chair.

New Members.—Dr. John Cunningham, Charles Kerr, George L. Denniston, John Sidey, and A. D. Austen, C.E.

The Chairman announced that Dr. Brown had presented the Institute library with a set of volumes of the International Scientific Series.

The discussion on Professor Brown's address on "The Economic Position of New Zealand," adjourned from last meeting, was then proceeded with, Messrs. W. D. Stewart, M.H.R., James Allen, M.H.R., Charles Kerr, D. White, and J. Ashcroft taking part in it.

THIRD MEETING: *12th June, 1888.*

A. Wilson, M.A., President, in the chair.

New Members.—Donald Reid, jun., and Robert Hay, C.E.

Papers.—1. "On the Alluvial Deposits on the Goldfields of Otago," by L. O. Beal. (*Transactions*, p. 382.)

The paper was illustrated by photographs.

2. "On the Fossil Marine Diatomaceous Deposit near Oamaru," by Dr. Harry de Lautour. (*Transactions*, p. 293.)

The paper was illustrated by numerous drawings and specimens of the deposits, while numerous slides were exhibited under microscopes in the library. The author gave a practical demonstration on the methods of cleaning and mounting diatoms for subsequent examination.

Exhibits.—Professor Parker gave an account of some recent interesting additions to the Museum, including—

(*a.*) Two penguins, showing both immature and adult plumage.
(*b.*) A cast of the fossil reptile *Compsognathus.*
(*c.*) Specimens of the "bladder-worm" taken from the muscles of a rabbit.
(*d.*) A collection of stuffed New Zealand fishes intended for the Melbourne Exhibition.

FOURTH MEETING: *10th July, 1888.*

Professor T. J. Parker, F.R.S., Vice-President, in the chair.

Dr. Hocken, on behalf of the members of the Institute, congratulated the Chairman on his having been elected a Fellow of the Royal Society, an honour which all who knew what Professor Parker had done in the cause of biological science, thought to be very well deserved. The Chairman, in acknowledging the compliment, stated that he considered the honour had been conferred on him chiefly on account of his researches on the embryology of *Apteryx*, and expressed the hope that before long all question of scientific importance in the colonies would be worked out by colonial workers, and that in future it would be unnecesssary for the Royal Society or other learned associations in England to send out specialists to solve our scientific problems, as they had done in the past.

Professor Parker exhibited and called attention to specimens of brown, Loch Leven, and Scotch burn trout prepared by his glycerine-gelatine process for the Tourists' Court in the Melbourne Exhibition.

Paper.—"On the Birds of the Lake Brunner District," by W. W. Smith; communicated by Geo. M. Thomson, F.L.S. (*Transactions*, p. 205.)

FIFTH MEETING: *14th August, 1888.*

A. Wilson, M.A., President, in the chair.

New Member.—A. Purdie, M.A.

Dr. Hocken delivered an exceedingly interesting lecture on "The Early History of Otago," being the ninth of the series on "The Early History of New Zealand."

Sixth Meeting: *11th September, 1888.*

A. Wilson, M.A., President, in the chair.

Professor Parker gave an account of the methods now adopted in the best natural-history museums of mounting animals in as naturalistic a manner as possible, and exhibited a number of photographs (taken by Mr. A. H. Burton) of New Zealand birds so grouped, with their appropriate surroundings.

Professor Parker also exhibited a series of diagrams, intended for use in the Otago Museum, illustrating the distribution of animals in geological time.

Papers.—1. "On the Distribution and Varieties of the Freshwater Crayfish (*Paranephrops*) in New Zealand," by Charles Chilton, M.A. (*Transactions*, p. 237.)

Professor Parker congratulated the author on having worked out his subject in a thoroughly scientific manner, and expressed the hope that others would work out the questions of distribution of our New Zealand forms in as thorough a way.

2. "On a Striated Rock-surface from Boatman's, near Reefton," by George J. Binns, F.G.S. (*Transactions*, p. 335.)

3. "On the Conservation and Extension of the Amenities of Dunedin and its Neighbourhood," by Alexander Bathgate.

After an animated discussion, in which the Chairman, Messrs. Melland, Thomas Brown, and M. Cohen took part, it was unanimously resolved, "That a committee, consisting of Messrs. Adams, Brown, Bathgate, Dymock, Henderson, Hocken, Shelton, J. C. Thomson, White, Wilson, and Rev. R. Waddell, be appointed to draw up a memorial to the Mayor, asking him to convene a public meeting with the object of forming an association to carry out the aims of the paper."

4. "On some Nepheline-bearing Rocks (Nepheline-Phonolites) from the Neighbourhood of Dunedin," by Professor Ulrich.

Seventh Meeting: *9th October, 1888.*

A. Wilson, M.A., President, in the chair.

Dr. Hocken delivered a lecture on "The Early History of Otago," being the tenth of the series on "The Early History of New Zealand."

Mr. W. Martin, one of the immigrants to Otago by the "Philip Laing," expressed the pleasure which Dr. Hocken's lecture had yielded him and other "old identities," and moved a hearty vote of thanks to the lecturer, which was carried by acclamation.

ANNUAL MEETING: *13th November, 1888.*

A. Wilson, M.A., President, in the chair.

Papers.—1. "Descriptions of New Zealand Plants," by D. Petrie, M.A.

2. "Descriptions of New Species of New Zealand *Araneæ*," by P. Goyen.

3. A note by Mr. Goyen on *Gasteracantha ocellata*, a curious spider found in Norfolk Island, and described by Mr. Urquhart, of Auckland, was communicated by Mr. George M. Thomson. A specimen was also exhibited.

Professor Parker exhibited and made remarks on a number of New Zealand passerine birds which he had lately had remounted for the Museum. In each case the adult birds, the young, and the nest were mounted on the same twig, so as to bring all the specimens of the same species before the eye at once.

Professor Parker also exhibited a specimen of *Dinornis casuarinus* which had been ploughed up at Green Island by Mr. D. Mills. The majority of the bones were present, and evidently all belonged to the same bird, which was quite young, the epiphyses of many of the vertebræ not being ossified.

The annual report and balance-sheet were read and adopted.

ABSTRACT.

During the session eight general meetings have been held, at which two lectures were delivered, and ten papers were read.

The meetings have been remarkably well attended, and greatly increased interest has been shown by the members.

During the sitting of the Senate of the University of New Zealand, in Dunedin, the Council organized a *conversazione* in the University library (kindly lent for the occasion by the Otago University Council) on the 9th March, to which the members of the Senate were invited.

Early in May the Council brought under the notice of the Marine Department the desirability of making some provision whereby qualified members of the New Zealand Institute might take advantage of the trips of Government steamers to the outlying islands (Kermadec, Chatham, Auckland, Campbell, Macquarie, Antipodes, &c.) for purposes of scientific research. The Council regret that the Government have declined to accede to their request.

Twenty-one new members, including one life-member, have been added during the year. The number on the roll is now 154, of whom 10 are life-members.

The balance-sheet shows the total receipts for the year, including a balance of £85 0s. 2d. from previous year, to amount to £211 1s. 8d., and the expenditure to £128 4s. 8d., leaving a credit balance of £82 17s. 5d. The sum of £248 4s. 1d. is on fixed deposit in the Union Bank. The present balance of assets over liabilities, exclusive of the library, is £819 7s.

ELECTION OF OFFICERS FOR 1889.—*President*—Dr. de Zouche; *Vice-presidents*—J. C. Thomson and A. Wilson, M.A.;

Hon. Secretary—Professor Gibbons; *Hon. Treasurer*—E. Melland; *Council*—Rev. Dr. Belcher, Dr. Hocken, Professors Parker and Scott, F. R. Chapman, D. Petrie, and G. M. Thomson; *Auditor*—D. Brent, M.A.

The President delivered an address on "An Ancient Cosmogony."

Dr. de Zouche then took the chair, and thanked the meeting for the honour which they had conferred on him.

WESTLAND INSTITUTE.

ABSTRACT OF ANNUAL REPORT.

The number of members on the roll is 95.

During the year eleven ordinary and five special meetings were held.

The income of the Society amounts to £178 7s., the expenditure to £171 0s. 1d.; leaving a balance of £7 6s. 11d.

ELECTION OF OFFICE-BEARERS.—*President*—John Nicholson; *Vice-president*—Arthur Hassal King; *Treasurer*—J. W. Souter; *Trustees*—Captain Bignell, R. Cross, B. Durbridge, F. Eckman, — Scanlan, W. L. Fowler, C. E. Holmes, M. L. Moss, E. B. Sammons, J. N. Smythe, J. P. Will, R. Hilldrup.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

First Meeting: *11th June, 1888.*

The President, W. Colenso, F.R.S., in the chair.

The President delivered an address.

Exhibits.—1. Specimen of the *Clianthus*, in which the ordinary foliage of the plant was compacted into large masses or balls on the stem; sent by Mr. Balfour, of Glenross.

2. A fine specimen of the butterfly-fish (*Gasterochisma melampus*), received for the Museum from Dr. Spencer. The fish was cast on board one of the small coastal steamers by a wave off Cape Turnagain.

3. A pair of skins of the *Platypus;* presented by Mr. J. Vigor Brown.

4. An albino lark, presented by Mr. T. Moore, of Waimarama.

5. A number of living sea-anemones were exhibited by the Hon. Secretary—some from Wellington and some from Christchurch.

6. A bottle containing a quantity of quicksilver from the hot springs at Ohaeawai, Bay of Islands; from Mr. J. A. Smith.

Second Meeting: *9th July, 1888.*

The President, W. Colenso, F.R.S., in the chair.

Papers.—1. "On a Recent Find of Moa-bones in the Swamp at Te Aute," by A. Hamilton. Part I. (*Transactions*, p. 311.)

Specimens described in the paper were shown, and a vote of thanks was passed to the Archdeacon of Hawke's Bay, the Rev. S. Williams, for his kindness in assisting Mr. Hamilton in his search.

2. "Notes on some New Zealand Birds," by A. Hamilton. (*Transactions*, p. 128.)

Exhibits.—A number of carved calabashes and curios from Central America deposited in the Museum by Mr. College, were shown. Larger specimens of the growth of the *Clianthus* were exhibited by Mr. Balfour.

THIRD MEETING: *13th August, 1888.*

The President, W. Colenso, F.R.S., in the chair.

Papers.—1. "On the Neighbourhood of Te Aoroa, Northern Wairoa," by J. Harding, of Mount Vernon, Waipukurau. (*Transactions*, p. 336.)

2. "On the Mental Effect of certain Vowel-sounds," by R. C. Harding, Napier. (*Transactions*, p. 418.)

An interesting discussion arose on Mr. Harding's paper.

3. "A Legend of Raukawa," by T. Pine; communicated by the Hon. Secretary. (*Transactions*, p. 416.)

A very large number of exhibits was brought forward at this meeting; amongst others—A fine specimen of *Pteroceras*, brought by Mr. J. Harding from Maunganui; a number of slabs of polished greenstone, by the President, together with some old and historic Maori greenstones, a *tiki*, ear-drops, and a beautiful *mere* of historic fame. Mr. Stanton sent a very beautiful carved canoe-paddle and two *taiahas*. Three enormous tibiæ of the moa from the Te Aute Swamp, each 36in. long, together with a collection of carved boxes used by the Maoris for various purposes, were shown by the Hon. Secretary.

FOURTH MEETING: *10th September, 1888.*

The President, W. Colenso, F.R.S., in the chair.

Papers.—1. "The Moa and its Hunters," by L. Moore.

2. "On a Recent Find of Moa-bones in the Te Aute Swamp," by A. Hamilton. Part II. (*Transactions*, p. 311.)

3. "On Coloured Sheep," by Taylor White, of Herbertville. (*Transactions*, p. 402.)

4. "Pope, the English Poet," by W. Colenso, F.R.S.

Original letters of Pope were exhibited.

Specimens from the Kermadec Islands, presented by Mr. J. S. Large, were shown—among them a large *Patella*, also the skin of a tropic bird (*Phaeton rubricauda*), and a starfish.

The President read a letter from Mr. Balfour, of Glenross, concerning some experiments in fish-hatching at Glenross.

FIFTH MEETING: *15th October, 1888.*

The President, W. Colenso, F.R.S., in the chair.

Papers.—1. "Snow Scenes in the Southern Alps," by Taylor White, of Herbertville. (*Transactions*, p. 398.)

2. "Stray Notes on the New Zealand Owl (*Athene novæ-zealandiæ*)," by W. Colenso, F.R.S. (*Transactions*, p. 200.)

In the course of the discussion which followed, Mr. Colenso quoted the fable of the "Battle of the Birds," recorded by him in the eleventh volume of the "Trans. N.Z. Inst.;" calling attention to the significant absence of the moa from the birds enumerated, and considered the omission a valuable piece of negative evidence in support of his contention that the Maoris did not know of the moa as a living and existing bird.

3. "On some New Zealand Curios," by Taylor White. (*Transactions*, p. 397.)

4. "On *Pyrameis gonerilla*," by W. Colenso, F.R.S. (*Transactions*, p. 196.)

5. "On a Chrysalis of an Unknown Species of Butterfly," by W. Colenso, F.R.S. (*Transactions*, p. 194.)

Exhibits.—A fine collection of minerals from the Collingwood district was sent by Mr. Washbourne, of Nelson, for the Museum.

Sixth Meeting: *12th November, 1888.*

The President, W. Colenso, F.R.S., in the chair.

Papers.—1. "On Fossil Moa-feathers from Gisborne," by H. Hill. (*Transactions*, p. 318.)

2. "On a New Species of *Hemideina*," by W. Colenso, F.R.S. (*Transactions*, p. 193.)

3. "On some New Species of Phænogamic Plants," by W. Colenso, F.R.S. (*Transactions*, p. 80.)

4. "On some New Species of Cryptogamic Plants," by W. Colenso, F.R.S. (*Transactions*, p. 43.)

5. "On a New Species of *Orobanche*," by W. Colenso, F.R.S. (*Transactions*, p. 41.)

A large number of mounted specimens of plants were shown to illustrate the papers read; also a number of fossils from the pumice-beds at Gisborne—leaves, small fish, and feathers.

NELSON PHILOSOPHICAL SOCIETY.

3rd September, 1888.

Dr. Boor, President, in the chair.

The Curator, Mr. Kingsley, exhibited some specimens of marble from Motueka, also some photographs of the grand waterfall in Milford Sound.

Paper.—"The Royston Cave (Hertfordshire, England), its History, Origin, and Use," by R. T. Kingsley.

Annual Meeting: *16th October, 1888.*

Dr. Boor, President, in the chair.

The Treasurer's report showed a balance in favour of the Society of £7 3s. 2d.

The Secretary's report, which included a retrospect of the various ordinary and Council meetings held during the past year, gave also a full report of the working of the School of Mines in connection with the Society.

The Curator's report showed that a very considerable number of specimens (chiefly mineralogical) had been added to the Museum during the past year, and chiefly at the hands of Mr. H. P. Washbourne.

Election of Officers for 1888–89.—*President*—The Bishop of Nelson; *Vice-presidents*—Dr. Boor and A. S. Atkinson; *Treasurer*—Dr. Hudson; *Secretary*—Dr. Coleman; *Council*—J. Holloway, R. T. Kingsley, Dr. Cressey, Dr. Mackie, and the Rev. H. Watson; *Curator*—R. T. Kingsley.

The President read a paper on "Germs, their Baneful and Beneficent Influence on the Human Organism."

November, 1888.

A. S. Atkinson, Vice-President, in the chair.

Mr. Washbourne presented a fine specimen of arragonite, and Mr. Leversay and the Curator a number of moa-bones

which they had collected in Aniseed Valley. The Curator also exhibited a coloured drawing of a curious fish cast ashore at Parapara, belonging, probably, to the order *Trachypteri.*

Paper.—"The Aphides and their Natural Enemies," by R. T. Kingsley.

APPENDIX.

Meteorology.

Comparative Abstract for 1888 and Previous Years.

Stations.	Barometer at 9.30 a.m.		Temperature from Self-registering Instruments read in Morning for Twenty-four Hours previously.					Computed from Observations.		Rain.		Wind.		Cloud.
	Mean Reading.	Extreme Range.	Mean Temp. in Shade.	Mean Daily Range of Temp.	Extreme Range of Temp.	Max. Temp. in Sun's Rays.	Min. Temp. on Grass.	Mean Elastic Force of Vapour.	Mean Degree of Moisture (Saturation 100).	Total Fall in Inches.	No. of Days on which Rain fell.	Average Daily Force in Miles for Year.	Maximum Velocity in Miles in any 24 Hours, and Date.	Mean Amount (0 to 10).
Auckland	30·052	1·330	57·5	12·4	43·5	153·0	29·0	·348	73	34·600	174	130	716 on 17th Aug.	5·9
Previous 24 years ...	29·976	...	59·1	...	...	...	...	·305	73	42·570	187	...		...
Wellington	29·912	1·566	54·4	12·5	38·3	151·0	27·0	·331	77	41·009	186	259	780 on 12th June.	4·2
Previous 24 years ...	29·921	...	54·7	...	...	...	...	·337	72	51·989	159	...		...
Dunedin	29·676	1·706	49·7	14·6	56·6	144·0	26·0	·273	75	48·356	157	164	600 on 11th Feb.	5·2
Previous 24 years ...	29·566	...	50·3	...	...	...	...	·277	74	34·839	164	...		...

Average Temperature of Seasons, compared with those of the Previous Year.

Stations.	Spring. September, October, November.		Summer. December, January, February.		Autumn. March, April, May.		Winter. June, July, August.	
	1887.	1888.	1887.	1888.	1887.	1888.	1887.	1888.
Auckland	56·1	55·4	67·4	62·8	62·5	59·5	52·0	52·4
Wellington	52·3	52·8	63·0	59·3	56·9	55·8	47·6	49·5
Dunedin	48·8	49·3	62·1	57·0	52·7	49·6	43·3	43·3

NOTES ON THE WEATHER DURING 1888.

JANUARY.—A fine month, with rainfall under the average, and moderate wind. Meteor observed at Wellington on 25th, travelling eastward; and slight earthquake felt at Lincoln on 19th.

FEBRUARY.—Rainfall below the average, and temperature also under; on the whole, fine weather. Earthquake felt at Wellington, slight, on 17th, at 7 a.m.

MARCH.—Rainfall in excess of average generally, and temperature on the whole below the average for this month. High wind prevailed. Earthquake at Wellington on 31st, at 7.30 a.m., slight, E. and W. High tides on 28th.

APRIL.—Rainfall about the average; temperature under average; generally fine weather. Earthquake at Wellington on 3rd, at 6.50 a.m., smart, N. and S.; and on 21st, at 6.55 a.m., slight.

MAY.—About the average rainfall, though at some places in excess; temperature about the average; seasonable weather. Earthquakes—at Rotorua on 29th, at 11.15 a.m., smart; and on 31st, at 2.15 p.m., smart: at Wellington on 3rd, at 2.15 a.m. and 6.4 a.m., slight; and on 4th, at 5 a.m., slight, and two sharp shocks at 8.25 a.m. Meteor on 4th, observed in Wellington, brilliant; and lunar halo on 20th with brilliant colours. At Dunedin an aurora observed on 11th.

JUNE.—On the whole, fine weather with moderate rain and wind, and the temperature about the average for this time of year.

JULY.—Showery weather, with strong N.W. and S.E. winds over centre.

AUGUST.—A wet month generally. Earthquake at Wellington on 16th, at 6.10 a.m., very slight; and 17th, at 7.20 a.m., slight: at Lincoln on 30th, at 10.30 p.m.

SEPTEMBER.—Very fine weather, with moderate winds and small rainfall. Earthquakes reported at Wellington on 1st, at 4.15 a.m., long double shock, E. to W.; on 5th, during night, slight, E. to W.; on 20th, at 10 p.m. slight: Amuri and North Canterbury on 1st, at 4.14 a.m., severe; also on 4th, 5th, and 9th, all smart: at Dunedin on 1st, at 4.15 a.m.

OCTOBER.—Rather wet weather towards end of month, but otherwise fine. Earthquakes—at Rotorua on 17th, at 8.15 p.m., smart, S.E. to N.W.: at Wellington on 23rd, at 8.15 p.m., two shocks, moderate; and on 26th, after midnight, sharp: at Lincoln on 12th, 2.25 a.m.; and on 23rd, at 8.19 p.m.

NOVEMBER.—Showery weather prevailed during this period, with strong S. and W. winds. Earthquake reported at Dunedin on 23rd.

DECEMBER.—Generally fine pleasant weather and moderate winds, except strong from N.W. over centre. Earthquakes—at Wellington on 8th, at 7.10 a.m., slight: at Lincoln on 27th, at 9.30 p.m.; on 31st, at 9 p.m.: at Dunedin on 27th.

EARTHQUAKES reported in NEW ZEALAND during 1888.

PLACE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Taupo ..	..	..	..	..	..	..	..	..	..	12, 23*	..	..	2
Patea ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
Napier ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
Rotorua ..	..	..	..	..	29,* 31*	..	..	..	..	17*	..	..	3
Marton ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
Woodville ..	..	..	..	..	..	..	..	..	..	12, 23*	..	..	2
Hawera ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
Masterton ..	..	..	..	..	..	..	..	..	..	12, 23*	..	..	2
Wellington ..	..	17	31	3,* 21	3, 4*	..	..	16, 17	1,* 2,* 5, 20	12, 23,* 26*	..	8	16
Castlepoint ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
New Plymouth	..	..	..	..	21*	..	..	..	..	..	..	..	1
Feilding ..	..	..	23*	..	..	..	..	..	..	..	..	..	1
Wanganui ..	..	..	23*	..	..	..	..	..	..	23*	..	..	2
Blenheim ..	..	..	..	..	21*	..	..	..	..	23*	..	..	2
Nelson ..	..	..	..	..	21*	..	..	..	..	23*	..	..	2
Palmerston N.	..	..	..	..	..	..	..	..	..	23*	..	..	1
Manaia ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
Havelock ..	..	..	..	..	..	..	..	..	..	23*	..	..	1
Kaikoura ..	..	..	..	..	..	..	..	..	1*	23*	..	..	2
Greymouth ..	18	..	..	..	..	..	..	1, 2,* 30*	1,* 9*	23*	..	..	7
Westport ..	18*	..	..	..	..	..	..	30*	1,* 9*	23*	..	..	5
Hokitika ..	..	..	..	..	..	..	..	30*	1,* 9*	23*	..	..	4
Timaru ..	..	..	..	..	..	..	..	..	1*	23*	..	..	2
Lincoln ..	19	..	..	..	..	..	..	30*	..	12, 23	..	27	5
Christchurch ..	..	..	..	..	21*	..	..	30*	1,† 6	23*	..	..	5‡
Waikari ..	..	..	..	..	..	..	..	9*	1,* 9*	..	..	..	3
Rangiora ..	..	14	..	..	..	..	..	..	..	..	..	..	1
Dunedin ..	..	..	..	..	..	..	..	..	1*	..	23	27	3
Stewart Island	..	..	..	..	..	..	..	..	15*	..	..	..	1
Kaiapoi ..	19	..	..	..	..	..	..	..	..	..	..	..	1

‡ Frequent shocks during this month throughout the Canterbury District, that on the 1st being the most severe.

NOTE.—The figures denote the day of the month on which one or more shocks were felt. Those with an asterisk affixed were described as *smart*, those with a dagger as *severe shocks*. The remainder were only slight tremors, and no doubt escaped record at most stations, there being no instrumental means employed for their detection. These tables are therefore not reliable as far as indicating the geographical distribution of the shocks.

NEW ZEALAND INSTITUTE.

HONORARY MEMBERS.

1870.

DRURY, Rear-Admiral BYRON, R.N.
FINSCH, OTTO, Ph.D., of Bremen.
FLOWER, W. H., F.R.S., F.R.C.S.
HOOKER, Sir J. D., K.C.S.I., C.B., M.D., F.R.S.
MUELLER, Baron Sir FERDINAND VON, K.C.M.G., M.D., F.R.S.
OWEN, Sir RICHARD, K.C.B., D.C.L., F.R.S.
RICHARDS, Vice-Admiral Sir G. H., C.B., F.R.S.

1872.

GREY, Sir GEORGE, K.C.B., D.C.L.
HUXLEY, THOMAS H., LL.D., F.R.S.
STOKES, Vice-Admiral J. L.

1873.

BOWEN, Sir GEORGE FERGUSON, G.C.M.G., P.C.
CAMBRIDGE, The Rev. O. PICKARD, M.A., C.M.Z.S.
GÜNTHER A., M.D., M.A., Ph.D., F.R.S.

1874.

McLACHLAN, ROBERT, F.L.S.
NEWTON, ALFRED, F.R.S.

1875.

FILHOL, Dr.
SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S.

1876.

ETHERIDGE, Prof. ROBERT, F.R.S.
BERGGREN, Dr. S.

1877.

WELD, Sir FREDERICK A., G.C.M.G.
SHARP, Dr. D.

1878.

MÜLLER, Professor MAX, F.R.S.
TENISON-WOODS, Rev. J. E., F.L.S.

1880.

The MARQUIS OF NORMANBY, G.C.B., G.C.M.G., P.C.

1883.

THOMSON, Sir WILLIAM, F.R.S.
ELLERY, ROBERT L. J., F.R.S.

1885.

SHARP, RICHARD BOWDLER, M.A., F.L.S.
WALLACE, A. R., F.L.S.

1888.

McCOY, Professor F., C.M.G., Sc.D., F.R.S.
ETTINGSHAUSEN, Baron VON.
BENEDEN, Professor J. P. VAN.

ORDINARY MEMBERS.

[*Life-members.]

WELLINGTON PHILOSOPHICAL SOCIETY.

Allen, J. A., Masterton
Allen, F.
Allen, G.
Ashcroft, G.
Atkinson, A. S., Nelson
Baillie, Hon. Capt. W. D. H.
Baird, J. D., C.E.
Baker, C. A.
Bannatyne, W. M.
Barleyman, John, New Plymouth
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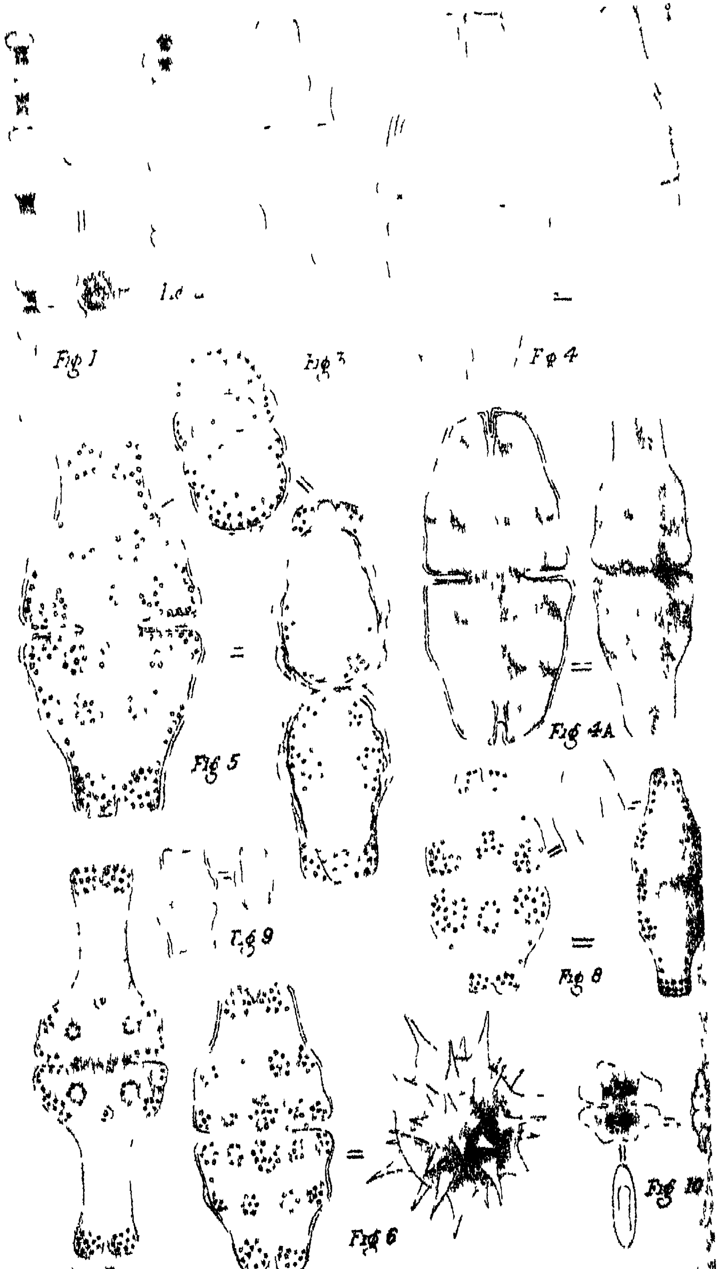

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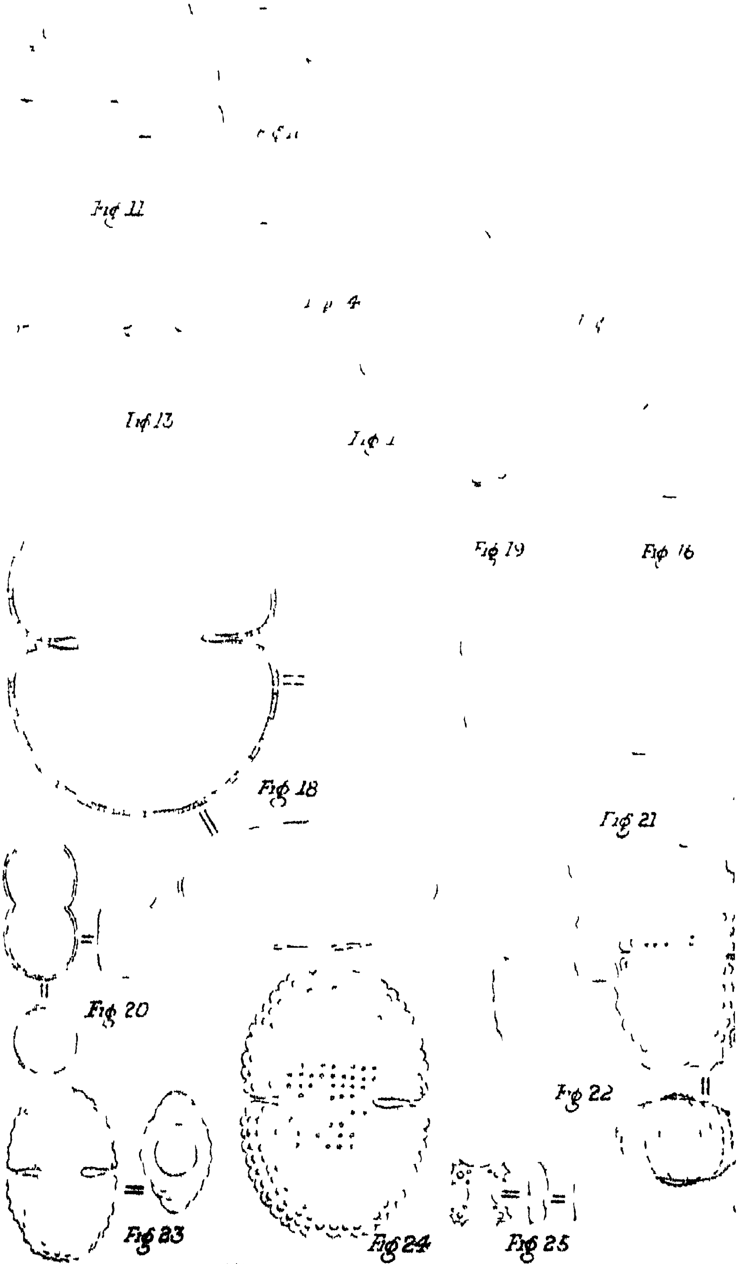

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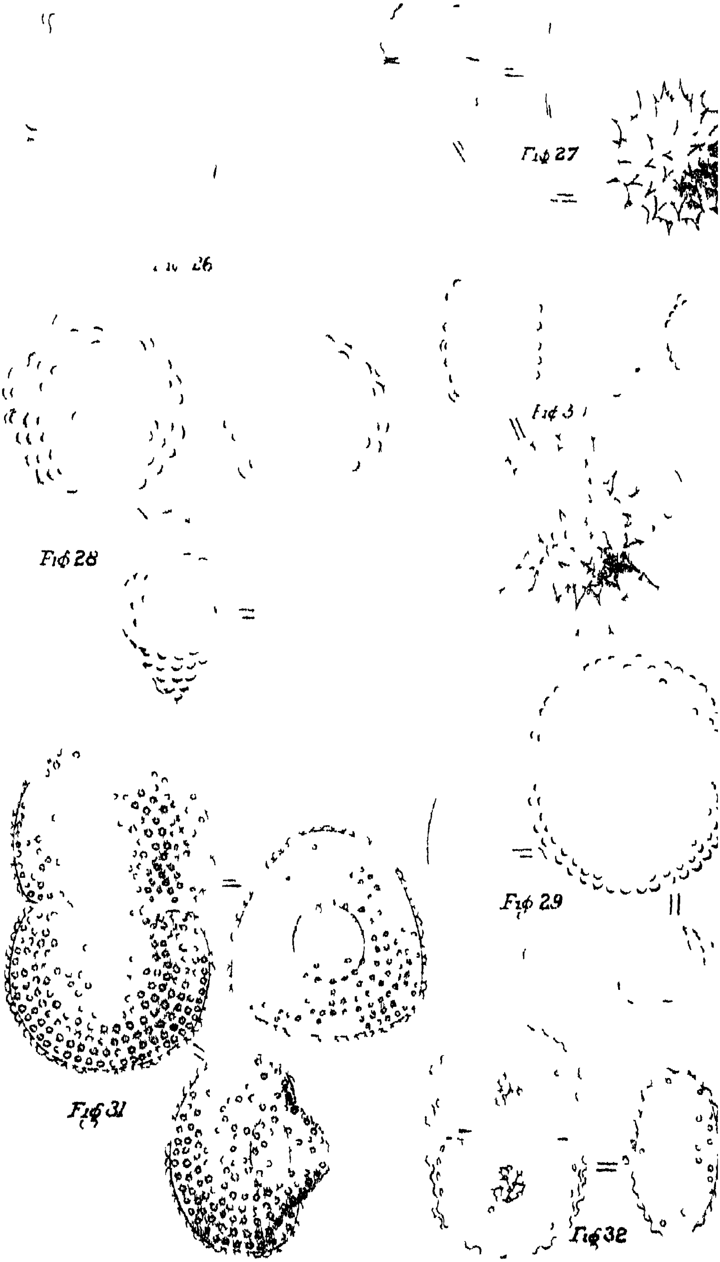

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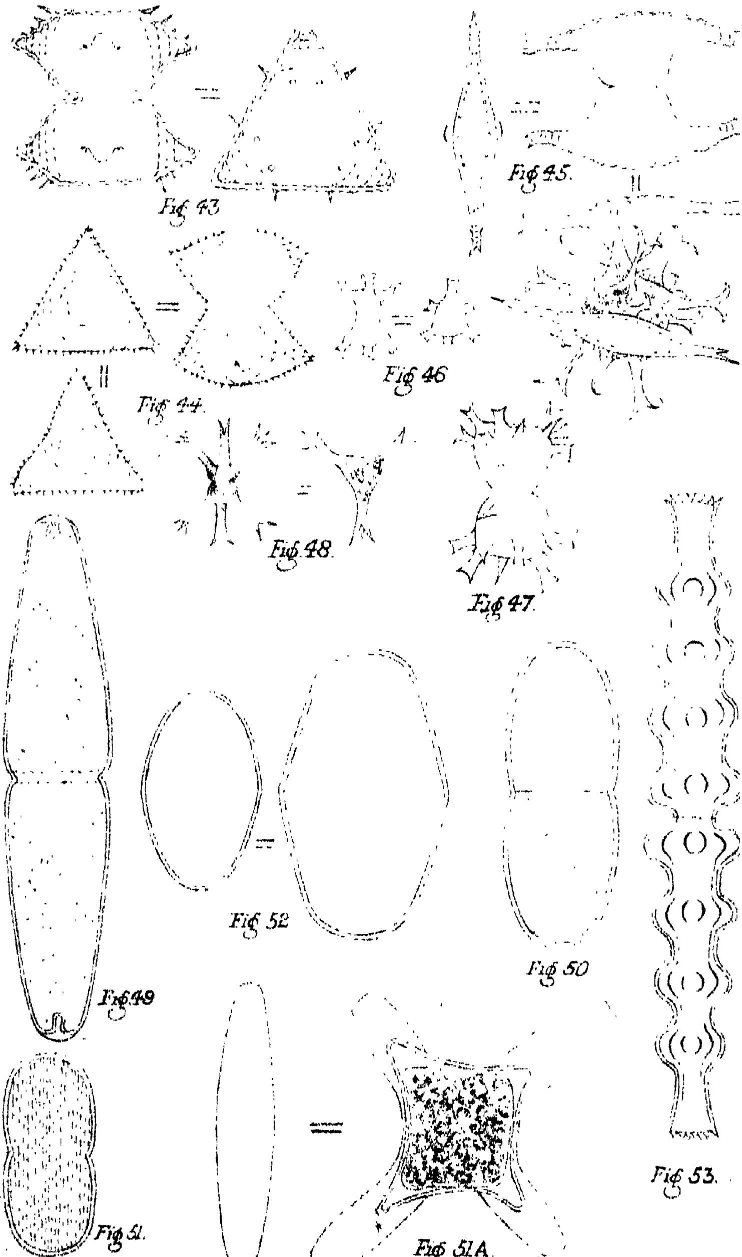

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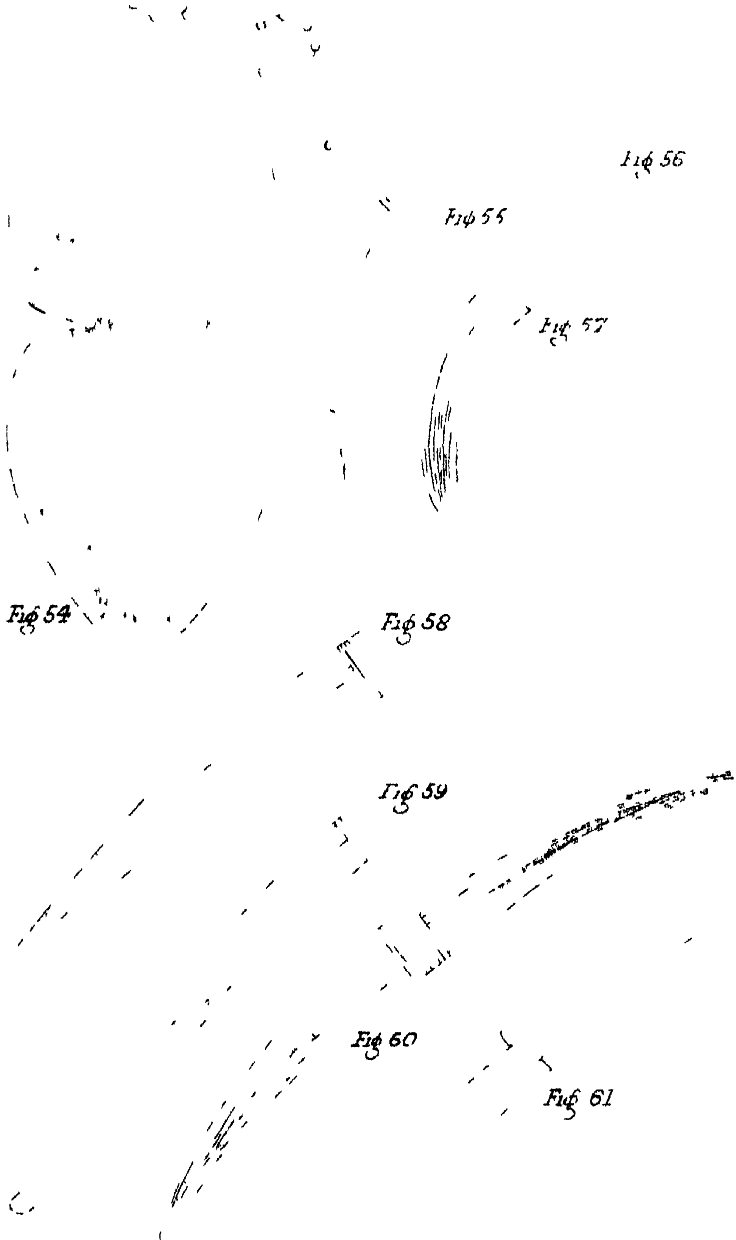

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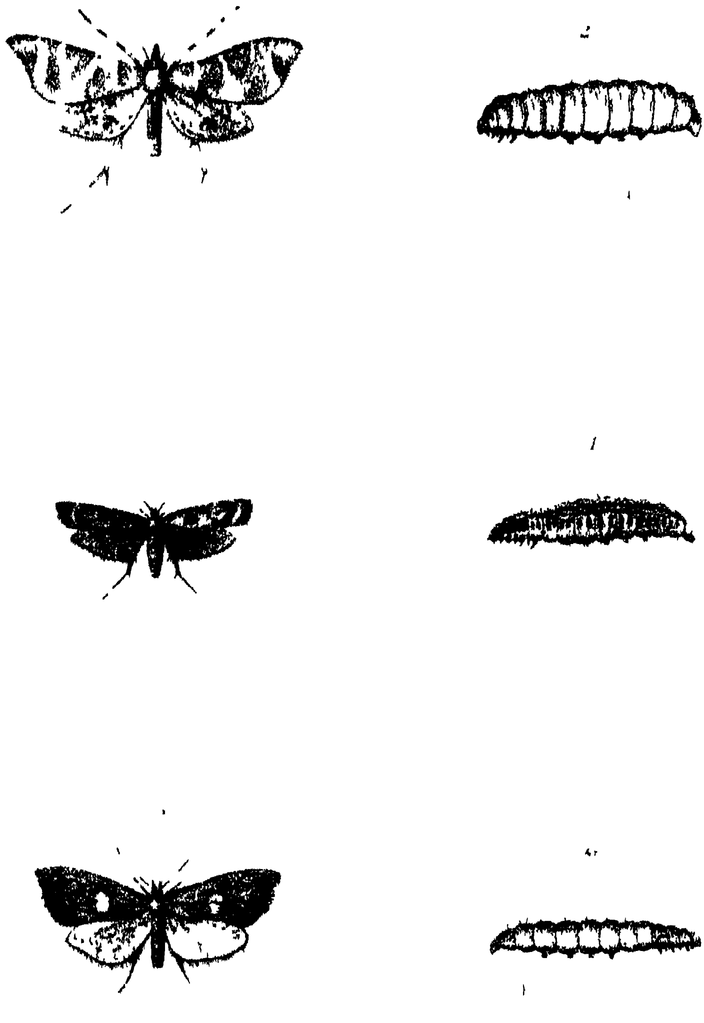

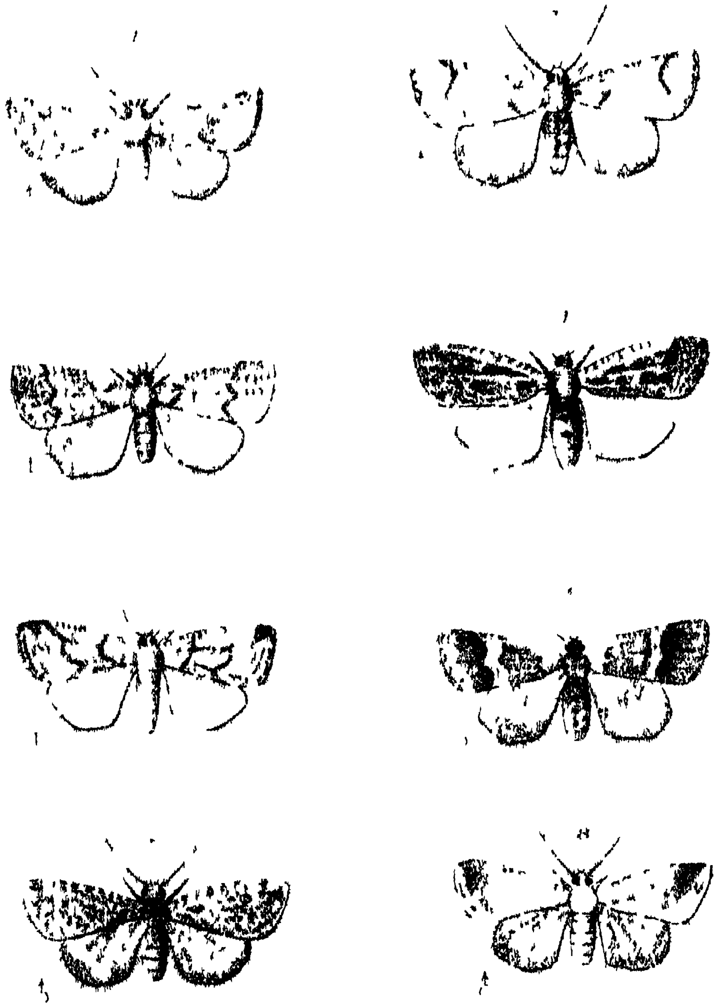

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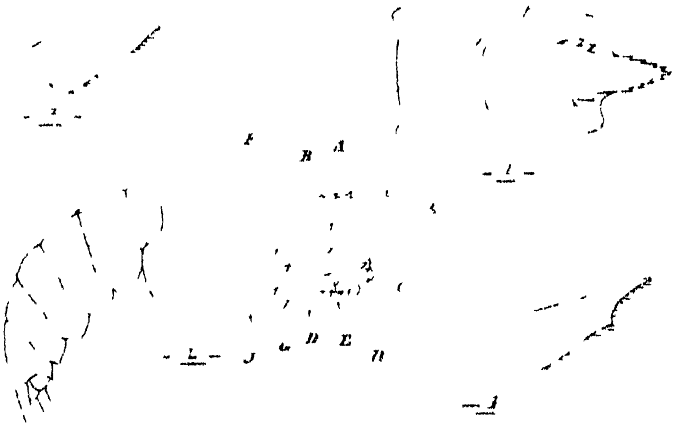
C B P del.



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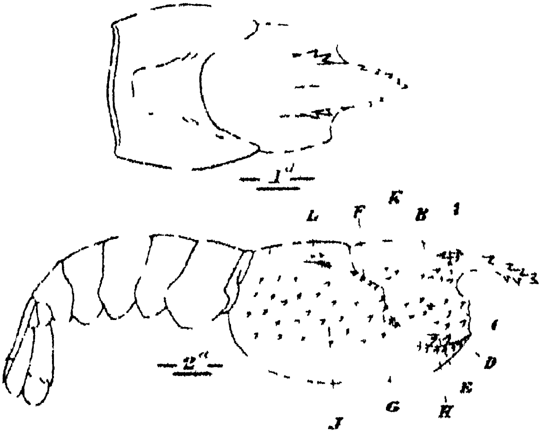

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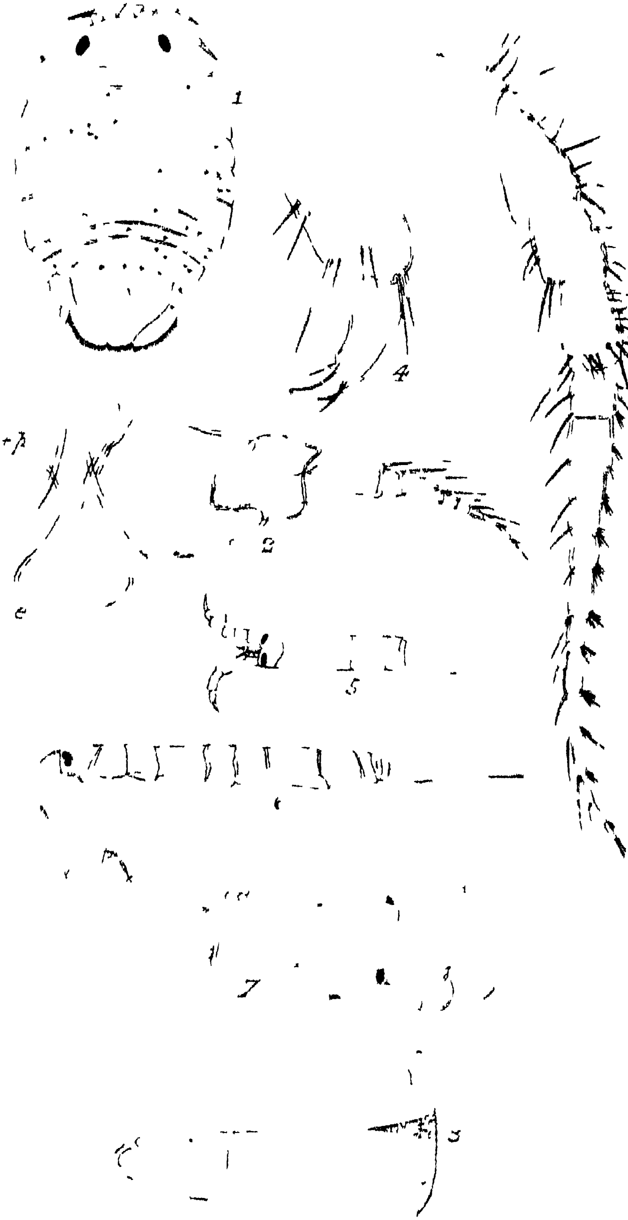

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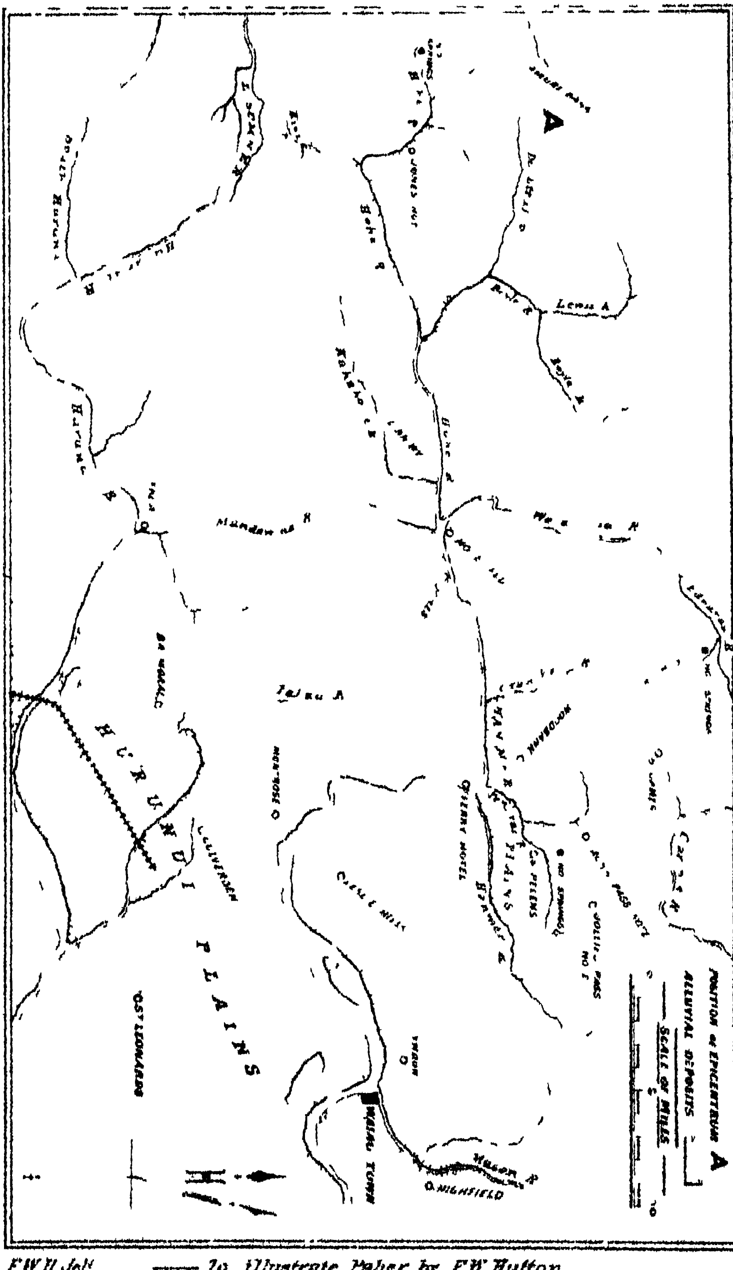

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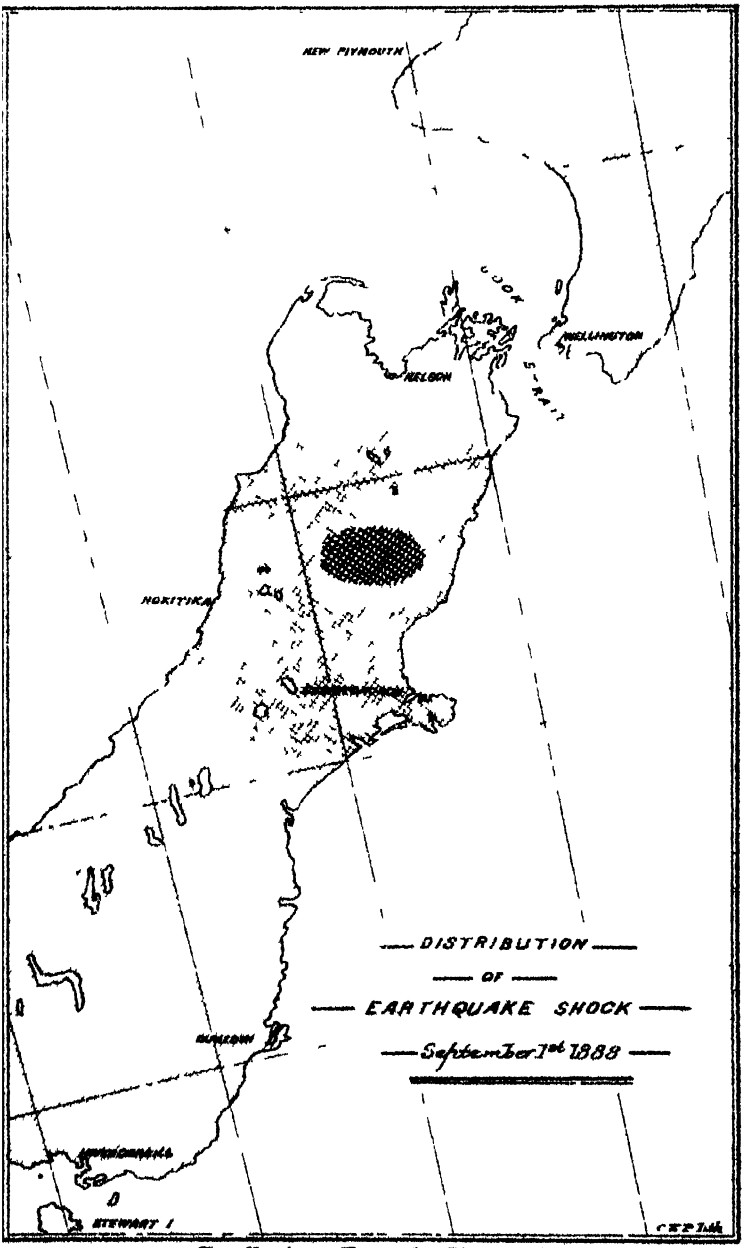

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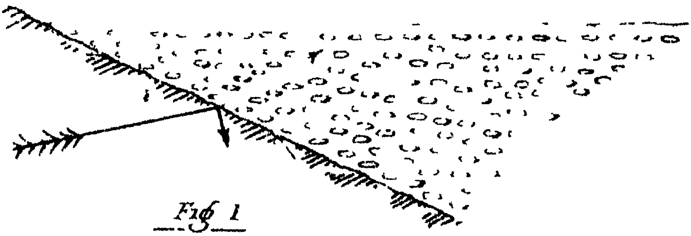

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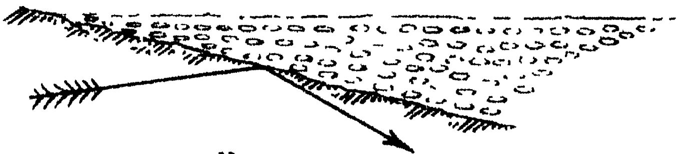

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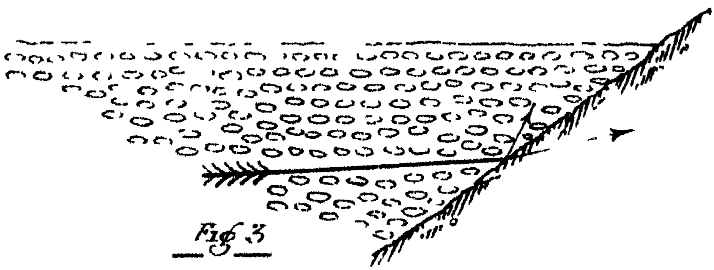

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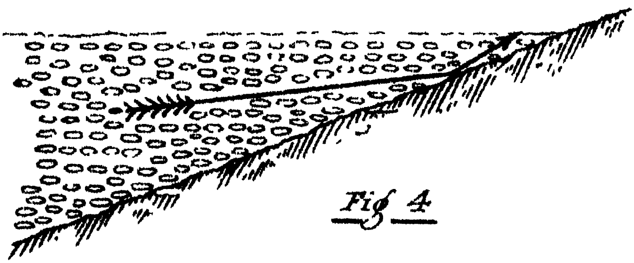

Fig 4

Reflection & Refraction of Earth-waves

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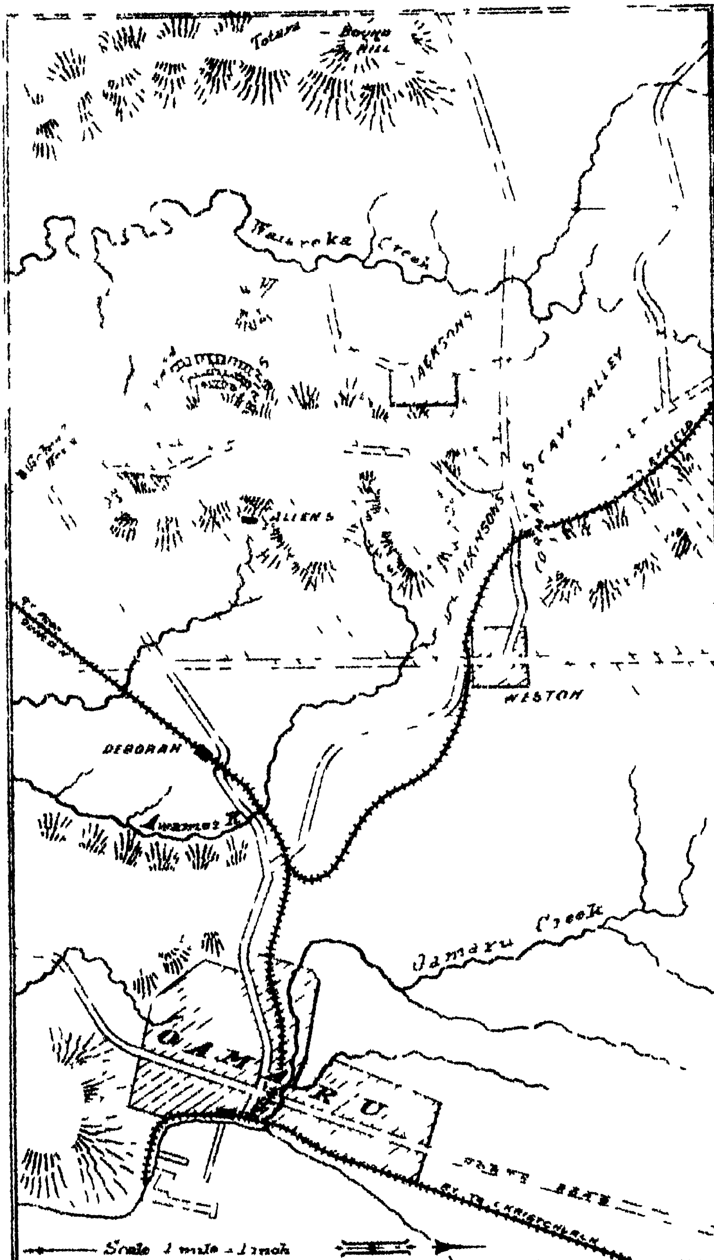

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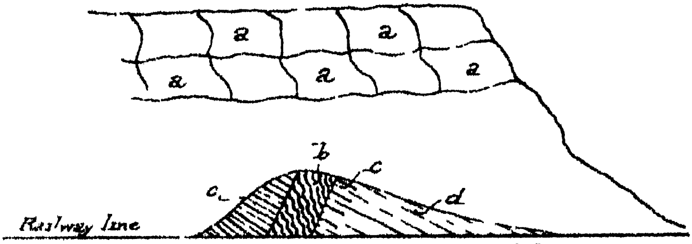
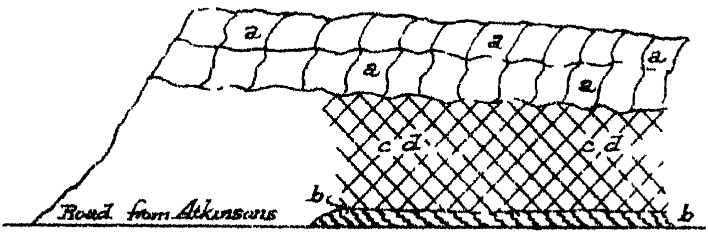
— CORMACK'S SIDING — Fig 1



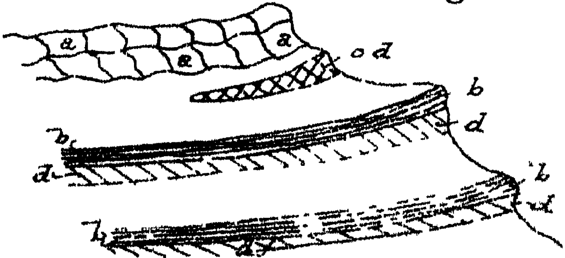
a Otatara limestone b Volcanic dyke.
c Altered semi fused diatomaceous ooze
d Diatomaceous ooze proper Non calcareous

— JACKSONS — Fig 2



a Otatara limestone
b Volcanic dyke & altered ooze Similar to Cormack's
c d Calcareous diatomaceous ooze

— BAINS — Fig 3



a Limestone b Volcanic tuff
c d Calcareous diatomaceous ooze Similar to Jacksons
d Non calcareous " " " " " Cormack's.

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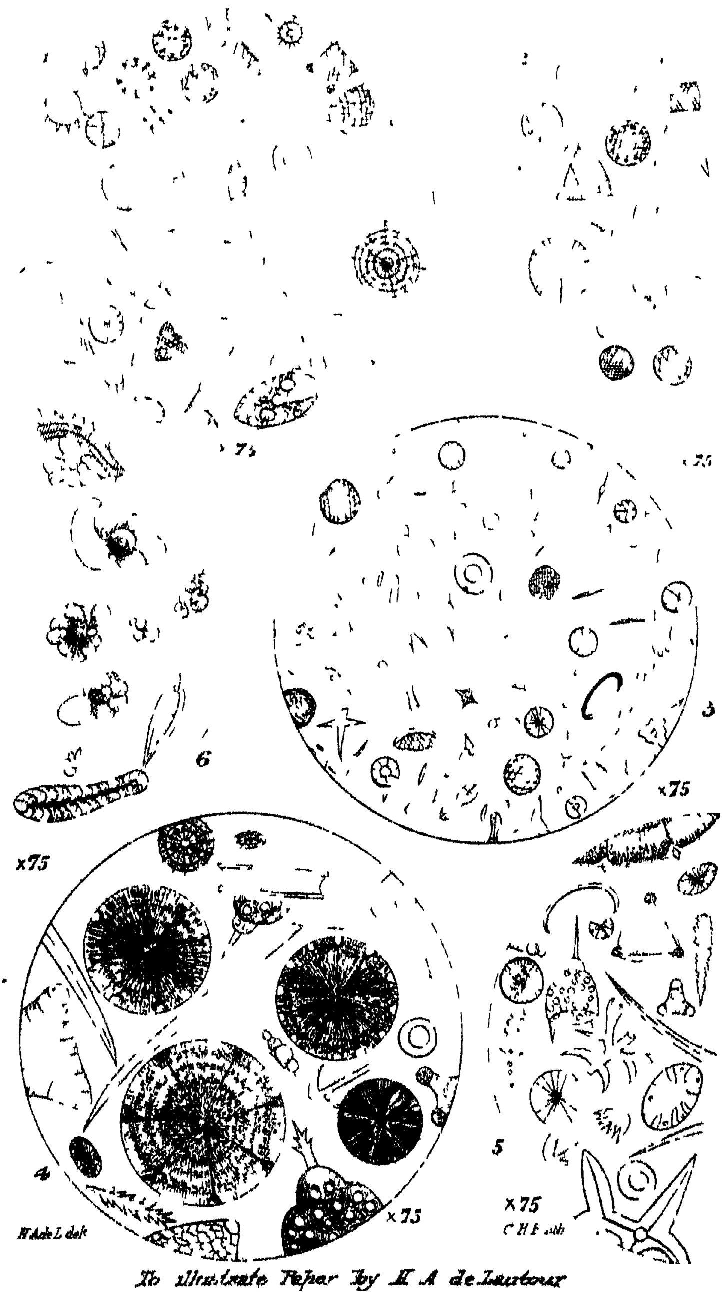

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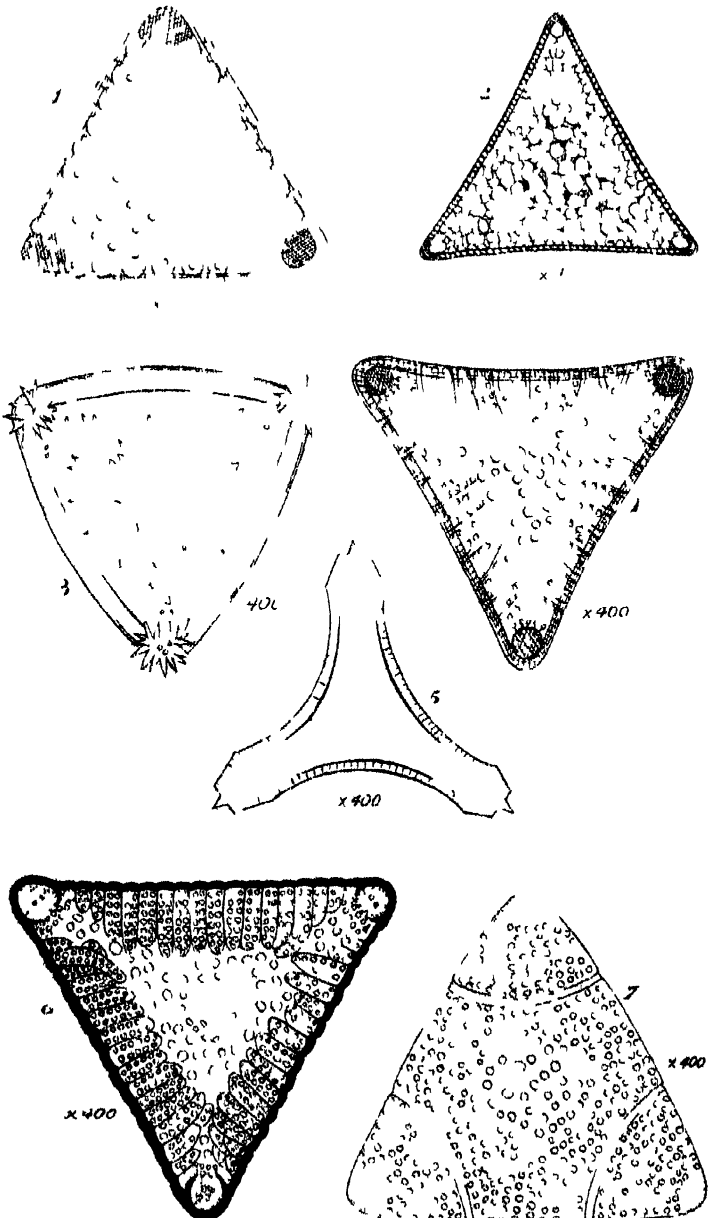

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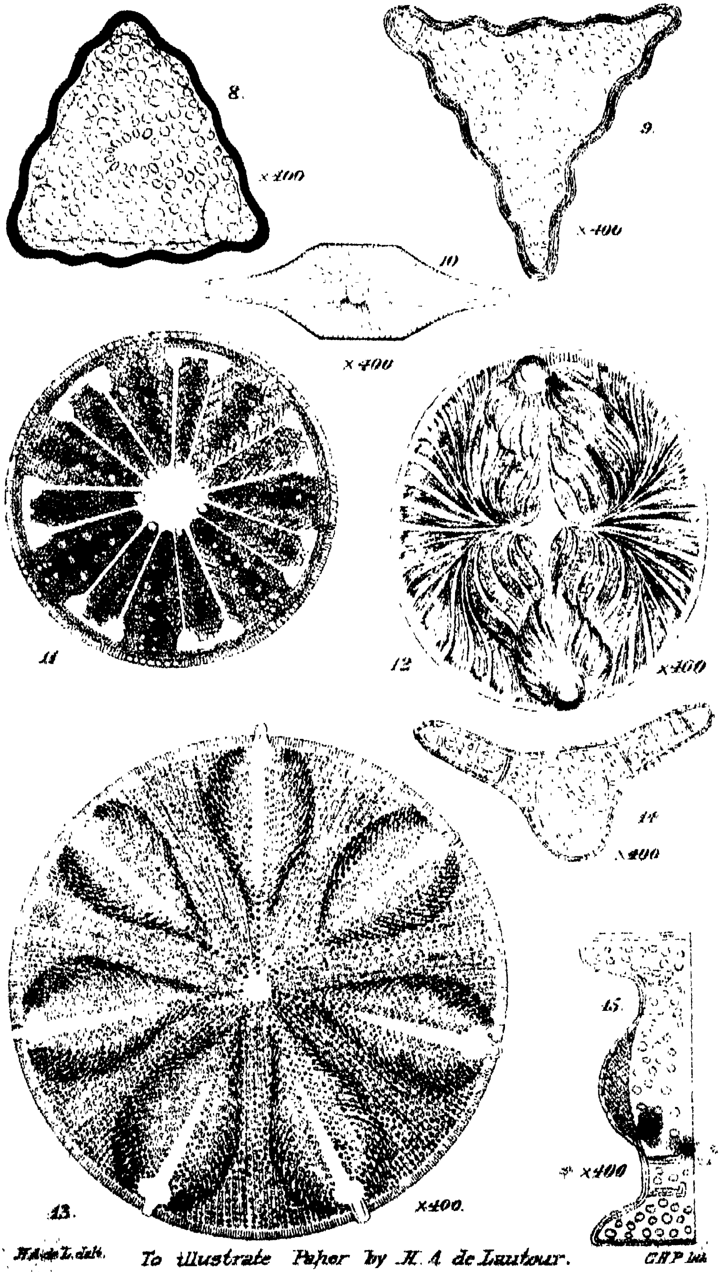

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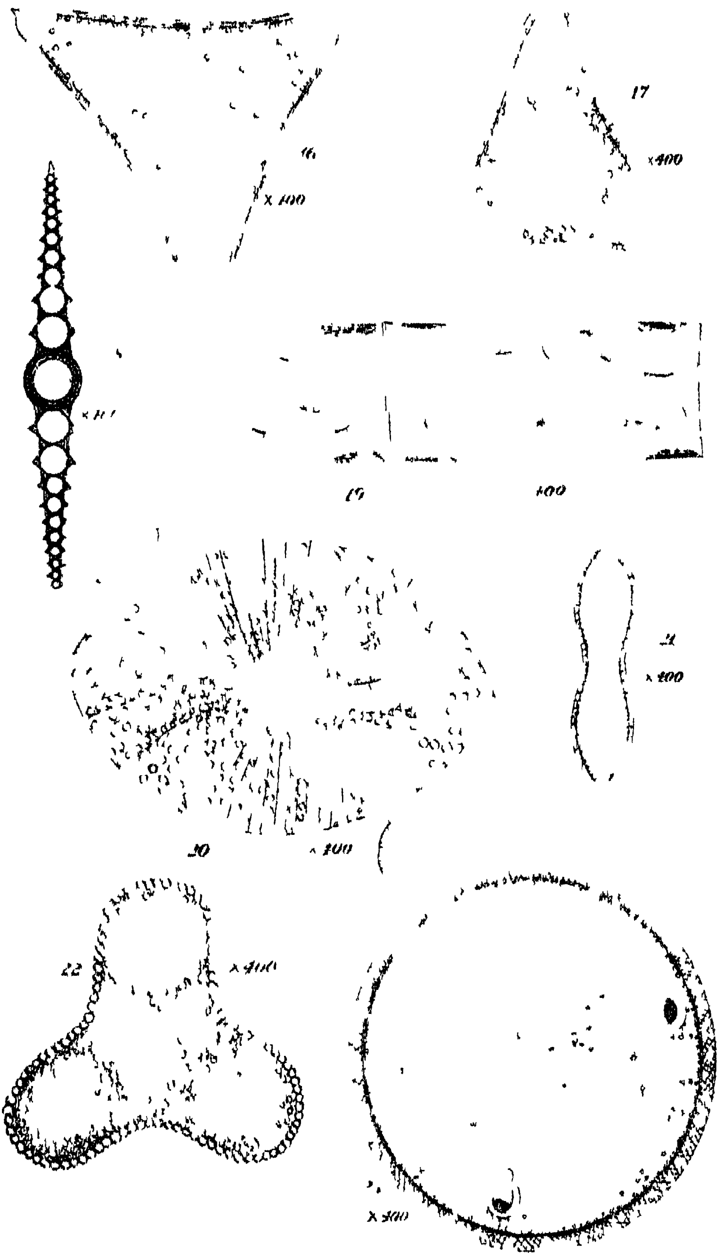

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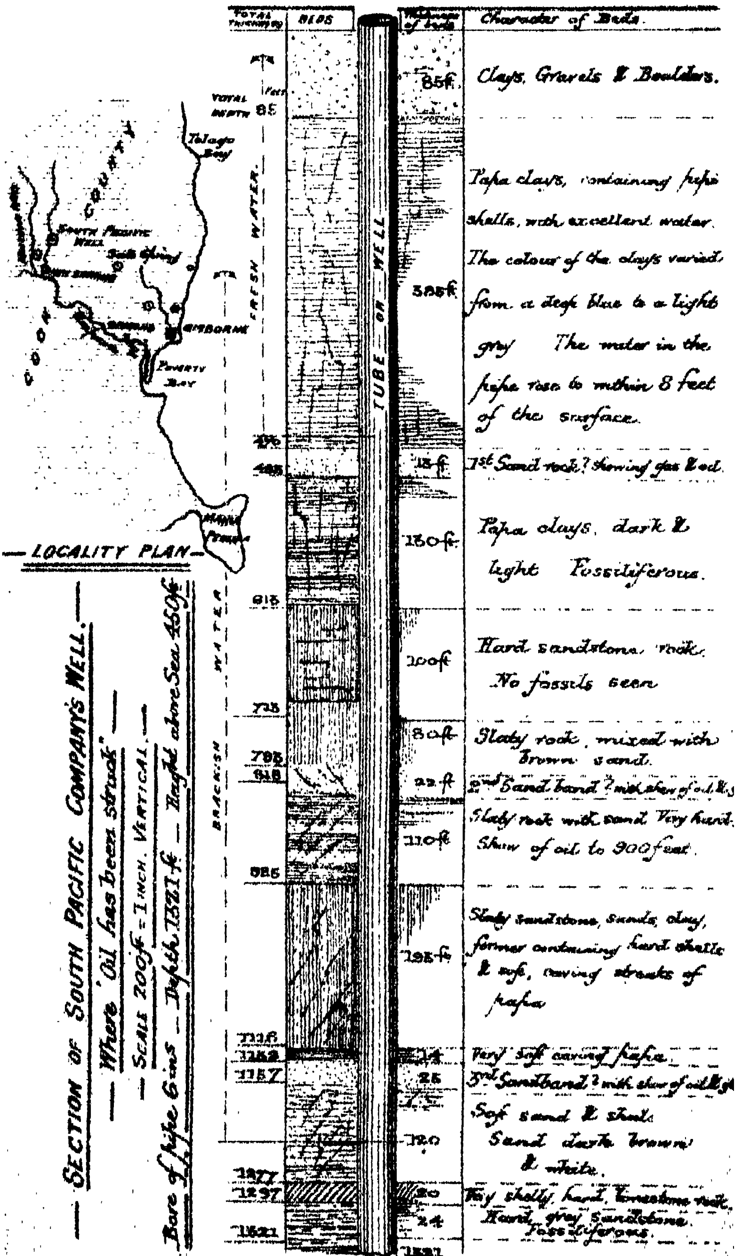

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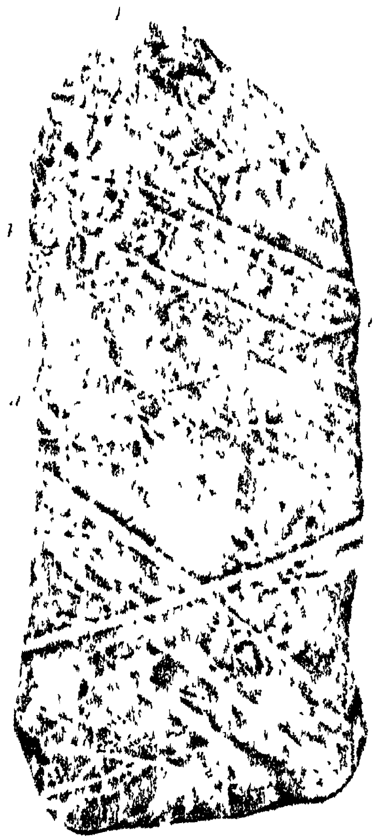


Natural Scale

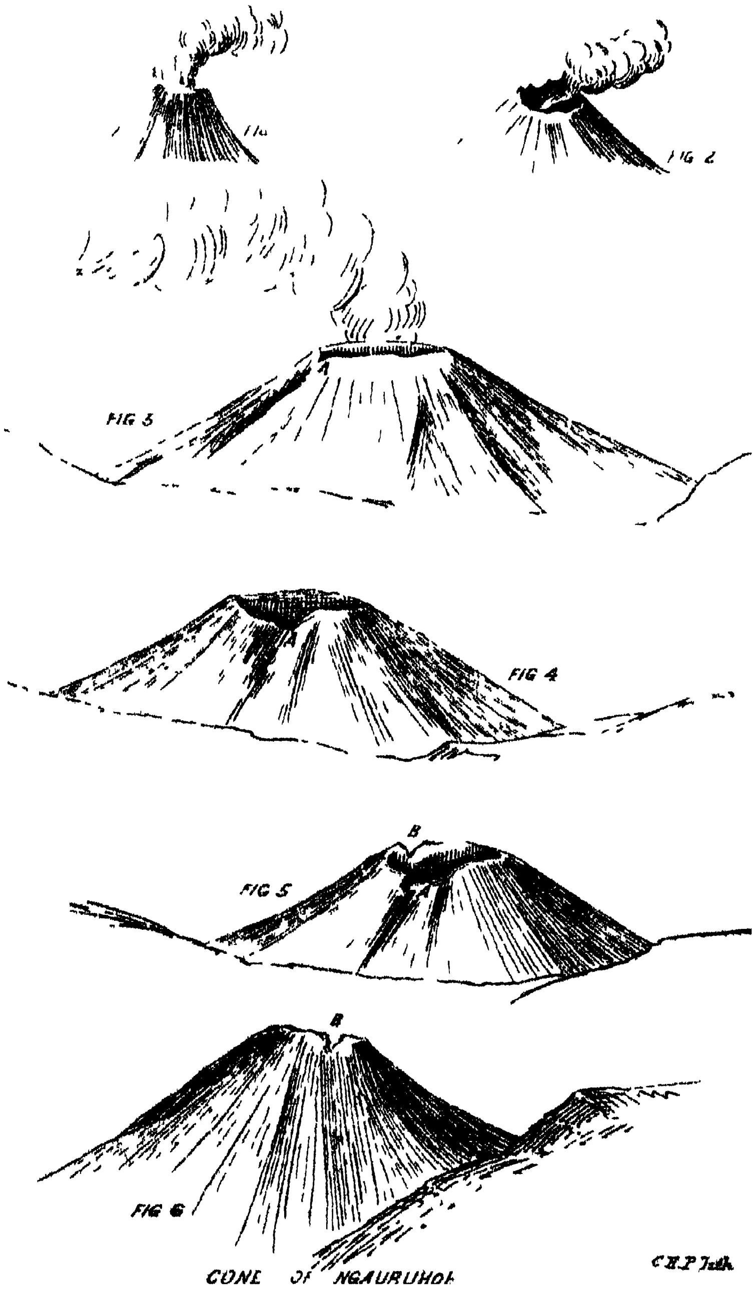
a a' and b b' are lines of fracture in the specimen.

A STRIATED ROCK SURFACE

From Boatman's Reefton N.Z.

G.T.B. del. C.H.P. lith.

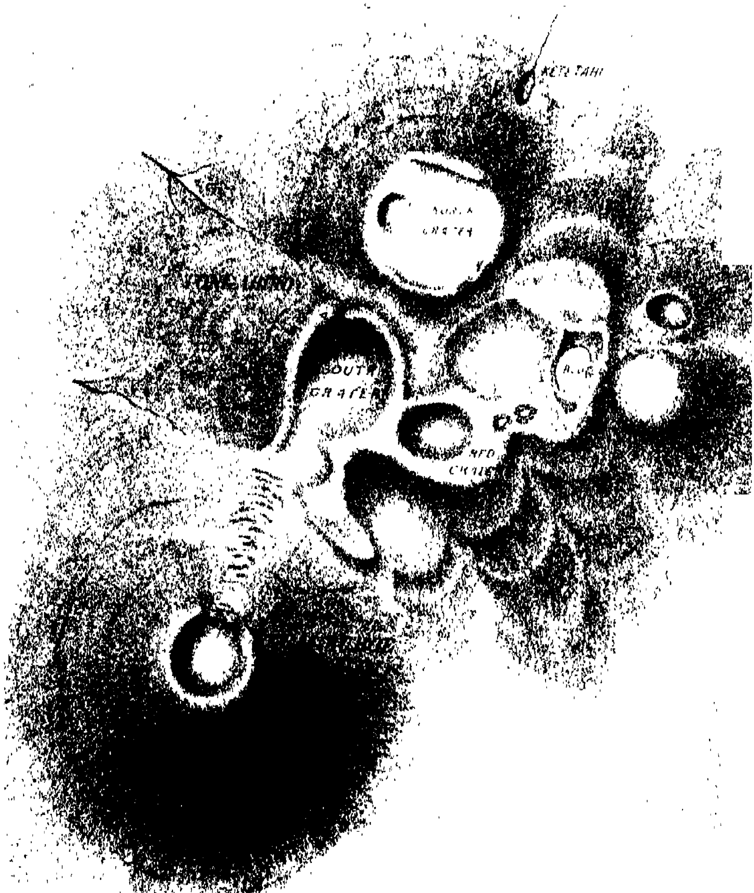
SOUTH END OF LAKE TAUPO — SHOWING VOLCANIC MOUNTAINS



CONE OF NGAURUHOE

C.H.P. lith.

TONGARIRO. SEEN FROM NEAR ROTO AIRA.

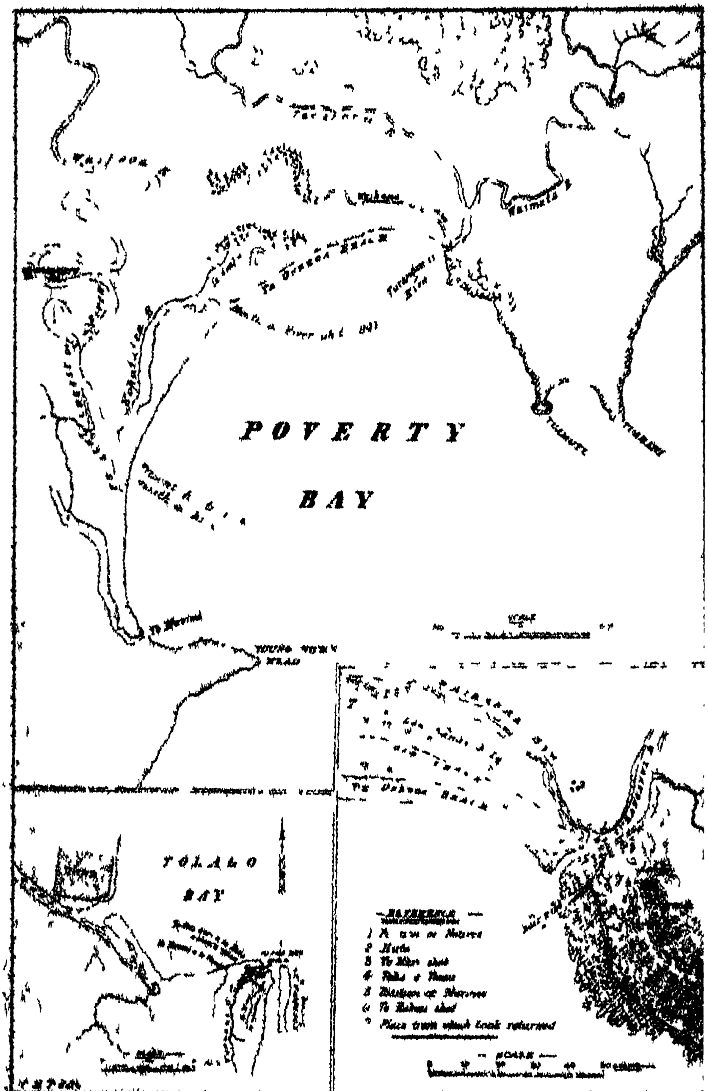


SKETCH MAP
OF THE
SUMMIT OF TONGARIRO.

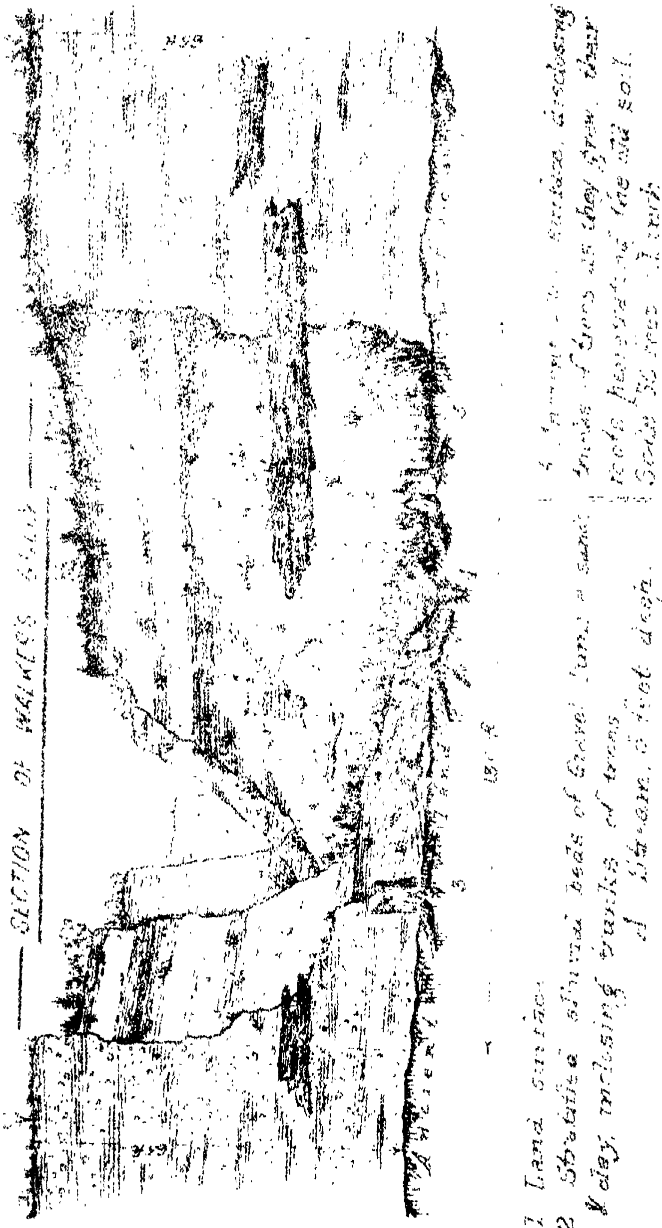
C.H.P. lith.

NORTH CRATER — TONGARIRO

LAKES ON SUMMIT OF TONGARIRO.



To illustrate Paper by Archdn W. L. Williams



T.H.J. del.

To illustrate Paper by L. Cussen.

C.N.F. Lith.

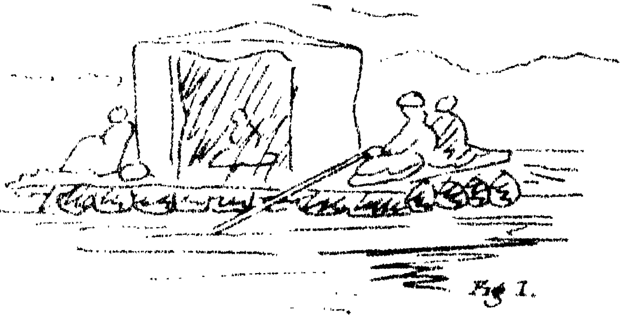


Fig 1.

Fig 2

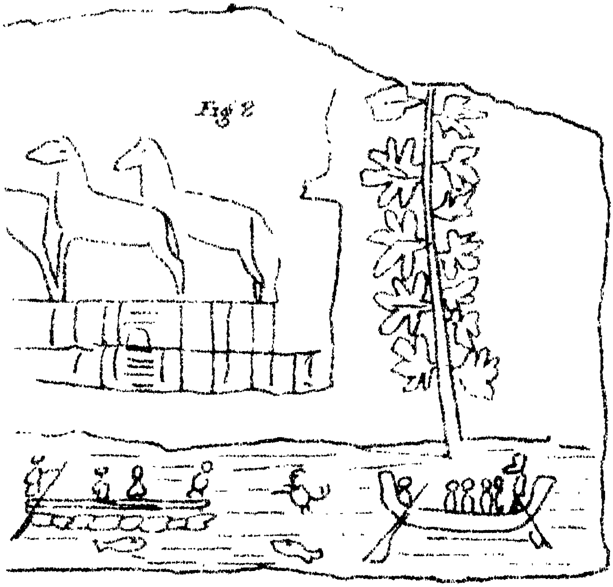
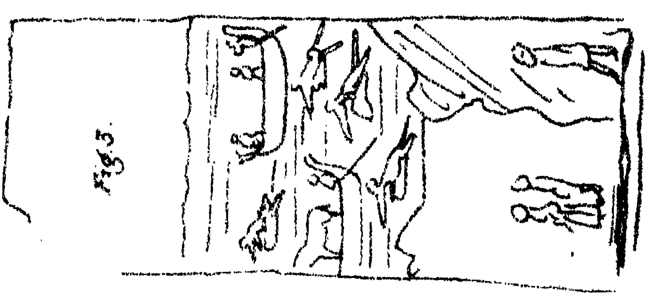


Fig 3.



E. T. delt

To illustrate Paper by E. Tregear

Date of issue.	Date of issue.	Date of issue.